The Real Effects of Protecting Biodiversity

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Abstract

As protected areas become a key policy tool for biodiversity conservation, their broader economic and corporate impacts remain underexplored. This study examines how proximity to newly designated protected areas affects corporate operations, environmental performance, and financial outcomes. Using data from 1990 to 2021, we show that industrial facilities near these areas significantly reduce toxic emissions, primarily through scaled-back production and workforce contraction rather than proactive investments in pollution control. Heightened regulatory scrutiny imposes operational constraints, leading to financial burdens for parent companies and measurable declines in profitability and stock market valuations. Further analysis identifies environmental enforcement actions near protected areas as the primary channel through which exposure to biodiversity conservation initiatives shapes corporate behavior. As global efforts to protect ecosystems expand, our findings highlight the substantial operational and financial risks firms face from biodiversity-related regulatory exposure, carrying important implications for policymakers, businesses, and investors.

Keywords: Biodiversity, Protected Areas, Regulatory Risk, Real Effects, Industrial Pollution, Spatial Finance

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1. Introduction

Biodiversity sustains human life and society, yet all global indicators reveal its alarming decline. In just the past 50 years, wildlife populations have plummeted by 73%, while human activities have degraded an estimated 75% of the Earth's land surface (WWF 2024). In response to this rapid loss of nature and the urgent need to preserve habitats for species survival, the Kunming-Montreal Agreement from the UN Biodiversity Conference (COP15) has galvanized 196 countries to commit to protecting 30% of the world's land and waters by 2030—a significant rise from the current 15% of land and 7% of oceans under protection.[1] This ambitious '30 by 30' target not only aims to mitigate biodiversity loss but also necessitates adjustments in regulatory frameworks that may challenge companies and financial market investors,[2] prompting them to adapt to new conservation-focused regulations. Despite the critical nature of these developments, evidence of the economic ramifications of expanding protected areas remains scarce. An in-depth understanding of these effects is crucial for governments assessing the trade-offs of protected area expansion and for companies and investors navigating biodiversity-related regulatory exposure and financial risks.

Our study is the first to quantify corporate exposure to biodiversity conservation through protected area designations by introducing a novel, location-based Corporate Biodiversity Exposure (CBE) measure. The CBE metric quantifies firms' biodiversity risk exposure by precisely identifying corporate facilities located in proximity to newly designated protected areas, thus capturing the ecological, regulatory, and reputational implications associated with these specific locations. Protected areas, as defined by the International Union for Conservation of Nature (IUCN), are geographic regions designated and managed through legal or other effective means to achieve long-term conservation of biodiversity and the associated ecosystem services and cultural values.[3] The establishment of these areas highlights their ecological, social, and cultural significance, prompting heightened public oversight, increased

[1] `https://education.nationalgeographic.org/resource/mapmaker-protected-areas/`

[2] In July 2024, *New Private Markets* reported that Temasek, the Singaporean state-owned investment firm managing US$288 billion as of March 2024, is exploring a nature-risk assessment tool to identify assets near critical biodiversity hotspots or protected areas. `https://www.newprivatemarkets.com/temasek-considers-nature-makes-first-direct-impact-investments/`

[3] `https://iucn.org/our-work/topic/effective-protected-areas.`

regulatory scrutiny, and intensified community engagement within their vicinity.[4] Thus, our CBE metric provides a nuanced evaluation of the regulatory and operational risks facing corporate production sites near protected areas, enabling a focused analysis of how proximity to conservation designations influences corporate environmental and financial outcomes. By linking facility-level exposure to biodiversity conservation with firm-level economic impacts, our study addresses three research questions: (1) How do protected area designations influence the operational practices of firms with facilities located near these conservation areas? (2) What specific strategies do firms adopt to implement these operational adjustments? (3) To what extent does a firm's exposure to biodiversity conservation, through the proximity of its production facilities to newly designated protected areas, impact its financial performance and valuation?

Our empirical analysis leverages a comprehensive panel of location-based CBE metrics, sourced from three key datasets: (1) the U.S. Environmental Protection Agency's (EPA's) Toxic Release Inventory, which tracks annual pollution prevention activities and toxic emissions at the facility level, (2) the NETS Publicly Listed Database, which provides detailed information on U.S. facilities (i.e., establishments) from 1990 to 2021, including addresses, annual sales, and employment figures, and (3) the World Database on Protected Areas (WDPA), managed by the UN Environment Programme (UNEP) and the IUCN. To quantify CBE, we focus on production facilities with reported toxic releases due to their significant potential ecological impact and public scrutiny.[5] We measure facility-level biodiversity exposure (CBE) by counting the number of protected areas within defined concentric rings surrounding the facility's location. This spatial approach captures the localized influence of protected areas on corporate behavior and enables a nuanced analysis of their impact on financial health and operational strategies. Finally, merging the CBE metric with financial information from Compustat and CRSP yields a detailed sample of 18,341 economic estab-

[4]See Pfaff and Robalino (2017) and Reynaert et al. (2024) for a comprehensive literature survey on the environmental and economic impacts of protected area policies within and beyond the protected estate. Recent studies (e.g., Bahrami, Gustafson, and Steiner 2024; Frank et al. 2025) assess the impacts of protected area governance and its associated land use restrictions on land values.

[5]Industrial activities threaten biodiversity through pollution, habitat destruction, and climate change. Our work focuses on pollution, which has profound and far-reaching effects on local wildlife, disrupting species across diverse ecosystems. Pollution can impair animals' respiratory systems, alter migration patterns, weaken immune defenses, and reduce reproductive success (see, e.g., Kelcey 1975; Newman 1979; Swarup 2005; Noyes and Lema 2015; Cristescu et al. 2016; Aulsebrook et al. 2020; Bertram et al. 2022).

lishments from 2,574 unique parent firms across the U.S. between 1990 and 2021, providing a robust basis to examine the relationship between biodiversity exposure and corporate decision-making.

We apply a continuous treatment intensity Difference-in-Differences (DiD) regression framework to assess the environmental impact of a firm's establishments' exposure to protected areas. This approach leverages the intertemporal designation of protected areas to introduce exogenous variation to the CBE metric while controlling for cross-sectional and temporal variations using facility- and parent firm-level controls, as well as facility, industry-year, and state-year fixed effects. Our findings reveal a significant association between higher CBE metrics and reduced on-site toxic chemical emissions into the air, ground, and water, highlighting the localized impact of protected areas. In economic terms, a one-standard-deviation increase in the CBE metric corresponds to a 31% reduction in on-site toxic releases, underscoring the substantial external impacts of protected areas on nearby economic activities.

Prior research suggests that protected area designations are often non-random and may correlate with local economic characteristics (Grupp et al. 2023; Reynaert et al. 2024). While our baseline analysis controls for fixed effects and focuses on establishments near protected areas rather than within them, where land-use restrictions are stricter, some residual concerns about selection bias may remain. To reinforce the causal interpretation of our findings, we implement an event-study DiD framework with identification tests to assess the localized environmental impacts of protected area designations on corporate facilities. First, we analyze first-time protected area designations and examine changes in toxic releases within a four-year window before and after a facility's exposure to a newly designated protected area. In a matched sample of control facilities located in the same states as the treated facilities, we observe a more-than-50% decline in on-site toxic emissions among treated facilities following first-time exposure. To further validate our findings, we conduct a falsification test on off-site toxic releases. Unlike the observed reduction in on-site emissions, we find no significant association between CBE and off-site toxic releases. This result reinforces the localized effect of protected areas, indicating that the impact is confined to on-site emissions rather than affecting off-site waste management practices.

We next investigate the mechanisms driving the reduction in toxic emissions for establishments near protected areas. Drawn from existing literature on corporate environmental policies (e.g., Akey and Appel 2021; Xu and Kim 2022), we explore two potential channels: (1) decreased sales and productivity due to environmental or regulatory constraints, and (2) increased investment in abatement technologies. Our analysis reveals that proximity to protected areas is associated with significant declines in sales, productivity, and workforce size for affected establishments. However, we find no evidence of increased investment in abatement technologies, suggesting that firms respond to biodiversity conservation pressures by scaling down production rather than adopting new environmental innovations.

These localized disruptions have broader financial consequences at the parent-company level. Our analysis shows that reduced economic activity at affected establishments contributes to firm-wide declines in profitability and stock market valuation, reflecting the financial risks associated with protected area designations. One likely contributor to these financial pressures is increased regulatory oversight. While protected areas do not directly impose land-use constraints on neighboring establishments, they heighten compliance requirements and public scrutiny, increasing enforcement risks and operational costs. To assess whether this heightened scrutiny drives the observed effects, we construct a set of regulatory risk proxies. Our findings indicate a strong association between the CBE measure and environmental enforcement actions, including violation penalties and EPA inspections, with firms experiencing greater biodiversity conservation exposure facing more frequent and severe penalties. Furthermore, the impact of CBE on toxic pollution is more pronounced for polluting plants and parent firms facing greater regulatory risk. This effect is especially evident near protected areas governed by public agencies rather than private entities, underscoring the critical role of public regulatory oversight in shaping corporate environmental practices.

Cross-sectional analysis shows that the observed effects are stronger among large polluters, likely due to heightened regulatory scrutiny. Consistent with research on financial constraints and environmental performance (Bartram, Hou, and Kim 2022; Xu and Kim 2022), we find that the CBE effect is weaker for financially constrained firms, emphasizing the importance of financial flexibility in meeting environmental standards. However, the CBE effect does not vary significantly across sectors with high environmental impact (e.g., manufacturing, mining) or those dependent on natural capital (e.g., agriculture, forestry).

Since firms in these sectors may depend on natural capital at different points in their value chain, sectoral classification alone may not fully capture their resource dependency in proximity to protected areas. In our final analysis, we conduct several robustness tests to validate our findings. Our results remain robust when using the Poisson Pseudo-Maximum Likelihood (PPML) estimator to correct for skewness in *raw* toxic pollution data, when accounting for the ecological significance or spatial characteristics of protected areas, and when incorporating the intensity of the production facilities' potential impact on nature, as proxied by size. Together, these findings confirm the robustness and generalizability of our results, demonstrating that the CBE effect persists across ecological, financial, and operational contexts.

Our study is the first to systematically evaluate how biodiversity protection through protected areas impacts firms, a critical yet overlooked aspect of the Kunming-Montreal Agreement from the UN COP15 conference. While protected areas are widely used as a global conservation strategy, research has largely focused on their environmental effects, such as deforestation and vegetation changes within and around these areas (Reynaert et al. 2024), with limited attention to their economic implications. Existing studies offer mixed evidence on the economic impact of protected areas. Bahrami, Gustafson, and Steiner (2024) report a 45% value discount on U.S. protected lands due to development restrictions, while Frank et al. (2025) find value appreciation for residential properties near critical habitats protected under the U.S. Endangered Species Act. In China, Chen et al. (2023) document higher public financing costs for municipalities with national nature reserves. Unlike these studies, we examine the impact of protected area designations on businesses in surrounding areas rather than within them. While these bordering regions are not subject to the same land-use restrictions, our findings show a sharp decline in firms' pollution emissions, suggesting that businesses near protected areas perceive heightened regulatory biodiversity risk and adjust their polluting activities accordingly. These results underscore the economic implications of biodiversity protection beyond protected area boundaries. Given the value relevance of our biodiversity exposure metric, we provide a transparent and accessible tool to help corporations measure nature-related risks using proximity to protected areas (TNFD 2022).[6] Our findings also support the application of spatial finance by financial actors to assess,

[6] The IBAT Alliance website (`https://www.ibat-alliance.org/user-stories`) lists a number of companies and investors that have already used the proximity to protected areas as a measure of nature-related risks. Key examples include Anglo American, Allianz, GlaxoSmithKline (GSK), Olam and the World Bank.

monitor, and manage biodiversity and natural asset impacts (The World Bank and WWF 2020).

Our research advances the field of biodiversity finance by establishing a direct link between corporate financial outcomes and biodiversity risk, an area gaining prominence in both academic and investment domains (Flammer, Giroux, and Heal 2023; Karolyi and Tobin-de la Puente 2023). Giglio et al. (2023) show that text-based biodiversity risk measures significantly influence equity prices at both the aggregate and firm levels, while Coqueret, Giroux, and Zerbib (2024) and Garel et al. (2024) demonstrate that corporate biodiversity risks have materially affected stock returns since 2021. Extending this research, our findings reveal that regulatory uncertainty from protected area governance is a key driver of biodiversity risk, directly linking firms' proximity to protected areas with financial performance and strategic decision-making. This strong relationship suggests that regulatory actions targeting firms' environmental threats to protected areas pose significant cash flow risks to both the firms and their parent companies. These results provide a theoretical basis for integrating biodiversity risk into investment decisions and asset pricing. More broadly, our study contributes to the sustainable finance literature (Starks 2023) by highlighting the regulatory and operational risks unique to biodiversity protection.

2. Protected Areas in the U.S.

Protected areas are designated lands aimed at conserving biodiversity, safeguarding ecosystems, and preserving sites of ecological and cultural significance. By restricting land use and enforcing environmental regulations, these areas provide a framework for preventing species loss, restoring endangered populations, and maintaining ecological balance. The United States has one of the largest and most diverse networks of protected lands, covering 1.23 million square kilometers—equivalent to 13% of the nation's total area and 9.25% of all protected areas worldwide (UNEP-WCMC 2025). The U.S. played a pioneering role in the global conservation movement, establishing Yellowstone National Park in 1872 as the world's first officially designated protected area. Conceived as an inviolate wildlife refuge, Yellowstone provided a model for conservation, allowing visitors to observe intact ecosystems and geological wonders. Its establishment set a precedent for future protected areas, shaping modern conservation policies both in the U.S. and globally.

The designation and management of protected areas in the U.S. are governed by a comprehensive legal framework, with national parks regulated under the National Park Service Organic Act and other protected areas under statutes like the Wilderness Act and the Federal Land Policy and Management Act. Broader environmental laws, including the Endangered Species Act (ESA) and the National Environmental Policy Act (NEPA), reinforce conservation by regulating activities that may impact these areas. However, protected area integrity depends not only on legal protections but also on external environmental factors, as habitat fragmentation, pollution, and climate change can undermine conservation efforts (Laurance et al. 2012). To address these threats, U.S. regulations extend protections beyond protected area boundaries. For instance, the Prevention of Significant Deterioration program, administered by the EPA, requires industrial facilities near protected areas to adopt Best Available Control Technology and conduct environmental impact assessments before development.[7] In addition to pollution control, a key driver of protected area expansion is the need to safeguard endangered species and restore biodiversity. The ESA designates critical habitats, which often overlap with or extend beyond protected areas, imposing restrictions on economic activities that threaten biodiversity. These land-use constraints influence regional economies, prompting industries near protected areas to shift toward sustainable alternatives such as ecotourism and conservation-friendly agriculture (Pfaff and Robalino 2017; Reynaert et al. 2024). This shift may have significant economic implications, requiring a balance between conservation priorities and economic development.

As biodiversity conservation expands, empirical data is essential for helping policymakers balance ecological benefits and economic impacts of protected area designations. Tracking the location and designation timeline of protected areas allows for a more precise evaluation of their effects on conservation efforts, land-use changes, and economic activity. To support such analyses, we source U.S. protected area data from the WDPA, the most comprehensive global repository of marine and terrestrial protected areas. Accessible via the Protected Planet website, it provides key details such as area identification, total size, status, and year of designation.[8] Jointly managed by UNEP and IUCN through the UNEP World

[7] `https://www.epa.gov/nsr/prevention-significant-deterioration-basic-information.`

[8] `http://www.protectedplanet.net.`

Conservation Monitoring Centre (UNEP-WCMC), the database is compiled in collaboration with governments, NGOs, academia, and industry partners. The WDPA has served as a central repository since 1981, shaped by earlier global conservation efforts, including a 1959 UN Economic and Social Council resolution recognizing the scientific, economic, and ecological importance of national parks.

The WDPA integrates U.S. protected area data from the Protected Areas Database of the U.S. (PAD-US), the official national inventory managed by the U.S. Geological Survey. PAD-US aligns with global conservation reporting standards, facilitating policy coordination and research consistency. As of September 2022, the U.S. has 42,824 protected areas, including 91 designated under international conservation frameworks, four regional, and 42,729 national protected areas. Among these, 42,813 are designated, with 11 designated as World Heritage Sites by UNESCO.[9] Figure 1 illustrates the geographic distribution of U.S. protected areas. The WDPA also tracks governance, classifying protected areas into four types: (1) government governance, managed by national or subnational agencies (9,124 federally controlled, 20,376 state/municipal oversight); (2) shared governance, jointly managed by multiple entities (122 protected areas); (3) private governance, overseen by non-profits or private landowners (11,877 protected areas); and (4) Indigenous and community governance, managed by Indigenous Peoples or local communities (three protected areas). Since 1990, 13,367 protected areas have been newly designated, with the most recent in 2019, averaging 445 designations per year, including status changes from "proposed" to "designated." Additionally, 23,605 designated areas lack recorded designation year data.

Protected areas serve diverse roles in biodiversity conservation, allowing varying degrees of human interaction, as outlined in the IUCN's six-category classification. Category I includes strict nature reserves and wilderness areas with minimal human activity (2,562 areas, averaging 366 km^2 each). Category II covers national parks, balancing conservation with limited public access (69 parks, nearly eight times the size of Category I areas). Categories III and IV focus on species and habitat conservation, comprising 2,164 protected areas. Categories V and VI allow for sustainable resource use, permitting some commercial activities while restricting large-scale industrial development. Though these account for the largest

[9] WDPA classifies protected areas into "proposed," "adopted," "established," "inscribed," or "designated." However, it only provides protected areas' attributes for their latest status and does not report the information related to their past status, including their size, governing body, or the date of status change.

share of U.S. protected areas (33,508 in total), they are significantly smaller, covering less than 20% of the area of Category I protected areas (see Online Appendix Table OA1 for detailed definitions of the IUCN categories).

3. Data and Research Design

The data for this study is sourced from multiple databases covering the period from 1990 to 2021: (1) Protected Area data for the U.S. comes from the WDPA. (2) Establishment-level information is obtained from the NETS Publicly Listed Database by Wall & Associates, combined with pollution data from the U.S. EPA's Toxic Release Inventory (TRI) and Pollution Prevention (P2) databases. (3) Financial data for publicly listed firms is from Compustat and CRSP.

3.1 Quantifying Corporate Biodiversity Exposure

3.1.1 The Main CBE Measure

Reliable data limitations pose a major obstacle to quantifying corporate biodiversity exposure, restricting efforts to assess biodiversity-related financial risks (Karolyi and Tobin-de la Puente 2023; O'Dwyer 2024). To overcome this constraint, early biodiversity research (Garel et al. 2024; Coqueret, Giroux, and Zerbib 2024) has often relied on heavily modeled data. For instance, S&P Global's nature risk metrics (introduced in 2021) and Iceberg Data Lab's (since 2018) use complex footprinting tools to estimate the pressures firms place on nature and their biodiversity impacts across the value chain. However, the intricate methodologies behind these models can obscure underlying assumptions and calculations, making full transparency difficult to achieve. An alternative approach quantifies firm-level biodiversity risk exposure using corporate financial disclosures. For example, Giglio et al. (2023) classify firms based on whether their 10-K statements contain at least two biodiversity-related sentences, finding that only 3.8% of firms mentioned biodiversity between 2015 and 2020. Similarly, Garel et al. (2024) document that just 5.0% of firms referenced biodiversity-related terms in earnings calls. Since many firms are still in the early stages of biodiversity disclosure, relying on textual analysis may provide an incomplete or imprecise assessments of firms' actual biodiversity risks.

To address these challenges, we propose a location-based approach that directly captures the impact of biodiversity conservation policies, aligning with the '30 by 30' target set in the Kunming-Montreal Agreement. Specifically, we introduce the corporate biodiversity exposure metric, CBE, which provides a transparent and systematic way to measure corporate biodiversity exposure. CBE quantifies exposure by counting the number of protected areas within a fixed radius of a firm's production establishment in a given year. The rationale behind this measure is that establishments operating near protected areas face stricter resource constraints, heightened environmental safeguards, and increased regulatory and reputational risks (TNFD 2022; WWF 2022). Establishments with no protected areas within the specified radius receive a CBE value of zero. Figure 2 illustrates an example of this metric, showing the proximity of an Eastman Chemical Company production site in Kingsport, Tennessee, to surrounding protected areas.

While CBE is straightforward to construct and interpret for stakeholders such as companies, policymakers, and investors, a few caveats should be noted. First, CBE is not a comprehensive measure of biodiversity risk, as it focuses primarily on firms' economic establishments and may overlook biodiversity-related risks embedded in their broader value chains. Second, CBE may not fully capture conservation efforts in unprotected areas, or biodiversity-related activities undertaken by other stakeholders. Nevertheless, CBE provides a granular and geographically diverse measure of corporate biodiversity exposure in the U.S., making it a valuable tool for addressing our research questions.

3.1.2 Alternative CBE measures

To ensure the robustness of our results, we develop five alternative CBE metrics that incorporate additional characteristics of protected areas and production establishments. These variations help assess whether our findings are sensitive to different ways of measuring corporate biodiversity exposure. The first alternative, $CBE_{IUCNCat}$, adjusts for the ecological importance of protected areas, recognizing that some play a more significant role in biodiversity conservation, particularly those hosting endangered species. To account for this, we assign weights to protected areas based on their IUCN category, with higher-priority categories receiving greater weights. Specifically, Category I protected areas are assigned a weight of six, while Category VI protected areas receive a weight of one, with intermediate categories weighted proportionally. $CBE_{IUCNCat}$ is then calculated as the number of protected areas within a fixed radius of each establishment, multiplied by their respective weights.[10]

Beyond ecological importance, we also consider the size of protected areas in two additional CBE measures. The second and third alternatives, CBE_{Area} and $CBE_{InteractionArea}$, incorporate the size of protected areas, recognizing that firms face greater regulatory, litigation, and reputational risks when operating near larger protected areas. CBE_{Area} is calculated as the natural logarithm of the total surface area of protected areas within a fixed radius surrounding an establishment in a given year. In contrast, $CBE_{IntersectionArea}$ refines this measure by accounting only for the portion of a protected area's surface that intersects with the fixed-radius buffer zone around the establishment. In addition to the characteristics of protected areas, we account for the size of production establishments in two alternative CBE measures. The fourth and fifth alternatives, $CBE_{Employment}$ and CBE_{Sales}, adjust for the size of the production establishment, acknowledging that larger facilities are generally perceived as higher risk due to their greater role in overall business operations. $CBE_{Employment}$ is computed as the number of protected areas within a fixed radius, multiplied by an establishment's share of total sample employment in a given year. Similarly, CBE_{Sales} scales the number of protected areas based on an establishment's inflation-adjusted annual sales figures.

3.2 Establishment and Firm-level Data

To capture firms' biodiversity footprints, we focus on production-related pollution by integrating two key datasets: establishment-level data from the NETS Publicly Listed Database and pollution data from the EPA's TRI and P2 databases. The NETS database provides comprehensive address-level data on U.S. establishments from 1990 to 2021, free from survivorship bias. It includes key establishment attributes such as annual sales and em-

[10] In the case of a missing IUCN Category value, we assign a weight of one to that protected area.

ployee count at each location. The TRI database is linked to the NETS database using establishment-level Duns & Bradstreet (DUNS) numbers to incorporate historical parent company names, parent company identifiers, annual estimated sales, and employment figures. To ensure consistency, we apply fuzzy matching combined with manual verification to reconcile historical parent names from NETS and TRI with firm names in Compustat and CRSP, ultimately assigning each firm a parent firm identifier (gvkey). Merging these datasets results in an initial sample of 165,500 establishment-year observations with complete information from all included sources.

For each establishment, we examine on-site and off-site toxic releases, inflation-adjusted annual sales, and employee count. On-site toxic releases (*On-Site Pollution*) refer to the amount of toxic chemicals (in pounds) released directly into the air, ground, or water at production sites, while off-site toxic releases (*Off-Site Pollution*) represent toxic chemicals transferred off-site for disposal. Given the localized nature of corporate exposure to protected areas, our analysis primarily focuses on the effects of CBE on *On-Site Pollution*, while *Off-Site Pollution* serves as a falsification test.

Following prior studies (Xu and Kim 2022; Fang, Hsu, and Tsou 2024), we control for the establishment size using the natural logarithm of the number of employees in a given establishment (*Ln(Workforce)*). In addition, we incorporate a series of parent firm-level characteristics as firm-level controls. Firm size (*Size*) is measured as the natural logarithm of the parent firm's market capitalization. *Tobin's Q* is calculated as the ratio of a firm's market value of assets to its book value of total assets, where market value of assets is measured as total assets minus the book value of common equity plus market capitalization. Financial leverage (*Leverage*) is defined as the sum of long-term debt and debt in current liabilities, scaled by the book value of total assets. Cash holdings (*Cash*) are computed as cash and short-term investments scaled by total assets, while $CAPEX$ is capital expenditure scaled by lagged total assets. Asset tangibility (*Tangibility*) is measured as net property, plant, and equipment scaled by lagged total assets, and financial profitability (*Profitability*) is defined as earnings before interest and taxes scaled by total sales. All variable definitions are provided in Appendix A. After compiling data from multiple sources, our final sample consists of 18,341 unique facilities linked to 2,574 parent companies from 1990 to 2021. To mitigate the influence of outliers, all continuous variables for establishments and firms are winsorized at the top and bottom 1% of the sample distribution. Summary statistics are presented in Table 1.

3.3 Empirical Methodology

Our baseline specification applies a continuous treatment intensity DiD empirical methodology (e.g., De Chaisemartin and d'Haultfoeuille 2018; De Chaisemartin and d'Haultfoeuille 2020; Bai, Jin, and Zhou 2024) to estimate the impact of corporate exposure to protected areas, measured using the CBE metric, on an establishment's environmental performance and real business activities. The panel regression for the continuous treatment intensity DiD is specified as follows:

$$Y^i_{j,t} = \alpha_0 + \beta_1 CBE^i_{j,t-1} + \beta_2 Ln(Workforce^i_{j,t}) + \Lambda' X^i_{j,t-1} + \gamma_j + \varphi_{ind,t} + \delta_{state,t} + \epsilon^i_{j,t} \quad (1)$$

where i, j, and t denote parent firm, establishment, and year, respectively. $Y^i_{j,t}$ represents the natural logarithm of *On-Site Pollution* by establishment j of parent firm i in year t. The key variable, $CBE^i_{j,t-1}$, measures corporate biodiversity exposure of establishment j's location in the previous year, $t-1$. Following WDPA recommendations, we exclude protected areas without designation years from our analysis (UNEP-WCMC 2016; UNEP-WCMC 2019).[11] To control for establishment size effects, we include the natural logarithm of the number of employees at establishment j, denoted as $Ln(Workforce^i_{j,t})$.[12] A vector of firm-level control variables, $X_{i,t-1}$, accounts for parent firm characteristics as discussed in the above section. The selection of protected areas is often a trade-off between commercial interests and ecological benefits (Jenkins, Van Houtan, Pimm and Sexton 2015; Alger 2023). To mitigate potential selection bias and control for omitted factors influencing protected area formations, we include establishment, industry-year, and state-year fixed effects, represented by γ_j, $\varphi_{ind,t}$ and $\delta_{state,t}$, respectively. The error term is denoted by $\epsilon^i_{j,t}$. Industry and state

[11] Alternatively, the WDPA suggests using the designation year as the first year of temporal analysis when it is missing. For robustness, we construct an alternative CBE metric by assigning protected areas without a designation year to one year before our sample period begins. Our results remain unchanged, as facility fixed effects account for time-invariant facility-level characteristics.

[12] $Ln(Workforce)$ is not lagged to account for the high correlation between firm establishment size and pollution emissions (Zhang 2025). However, our results remain qualitatively similar when controlling for lagged number of employees in the regression analysis.

classifications are assigned at the facility level, and robust standard errors are clustered at the establishment level.

Our empirical analysis selects a primary CBE metric that balances statistical power, economic relevance, and empirical robustness. This choice is guided by widely used biodiversity spatial analysis tools, particularly the Integrated Biodiversity Assessment Tool (IBAT), as well as suggestive evidence from our data. IBAT typically assesses proximity using 5-, 20-, and 50-km radii, and to improve granularity, we also consider 10-, 30-, and 40-km radii.[13] Given that pollutant dispersion plays a crucial role in biodiversity impact, we align our selection with established pollution diffusion patterns. Pollutant concentration generally declines with distance from the source due to atmospheric dispersion and deposition, the process by which particles eventually settle on the Earth's surface through precipitation or dry deposition.[14] Under typical conditions, the Gaussian plume model predicts that pollutant concentration decreases by approximately 95-99% within 30 kilometers, a pattern reflected in our sample: there is a strong negative association between CBE_{0-5km} and on-site toxic releases, but this effect weakens with distance and becomes indistinguishable beyond 30 kilometers as shown in Online Appendix Figure OA1.

Beyond pollution dynamics, the CBE metric must also capture a sufficient number of protected area designation events while preserving the economic significance of protected area exposure. Summary statistics across concentric rings (see Online Appendix Table OA2) reveal that CBE values are lower at shorter distances, reflecting the relative scarcity of protected areas near establishments. However, the environmental impact of protected area exposure is more pronounced at closer distances, as firms near protected areas pose a higher risk of environmental damage, assuming similar pollution technology. By 30 kilometers, more than 50% of sample firms have experienced at least one protected area designation event. Balancing designation frequency, economic significance, and pollution reduction effectiveness, we use the number of protected areas in the 30-km radius around an establishment as our primary metric throughout the analysis.

[13]The IBAT alliance includes Birdlife International, Conservation International, the IUCN, and the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC). https://www.ibat-alliance.org/about-us?locale=en.

[14]Fine particles (<2.5 μm) from toxic releases can travel hundreds to thousands of kilometers, while coarser particles (2.5-10 μm) typically disperse over distances of one to tens of kilometers, depending on wind, temperature, humidity, and atmospheric stability (Hinds 1999; Seinfeld and Pandis 2016).

To improve identification, we implement a stacked DiD design, focusing on the first-time designation of a protected area within a 30-km radius of an establishment. By isolating establishments' initial exposure to a protected area, this approach estimates the average adjustment period for operational responses following the designation. In this stacked DiD analysis, we construct cohorts of treated and control establishments within a [-4, +4] year window around the designation year ($t = 0$). Each cohort consists of one treated establishment that experienced the first-time designation of a protected area within a 30-km radius, along with control establishments located in the same state but did not undergo such a designation.[15] These cohorts are then stacked into a combined dataset for regression analysis, specified as follows:

$$Y^i_{j,t} = \alpha_0 + \beta_1 Treat^i_{j,c} \times Post_{c,t} + \beta_2 Ln(Workforce^i_{j,t}) + \Lambda' X^i_{t-1} + \gamma_{j,c} + \varphi_{ind,t,c} + \delta_{state,t,c} + \epsilon^i_{j,t}, \tag{2}$$

where i, j, and t denote parent firm, establishment, and year, respectively. $Y^i_{j,t}$ represents the natural logarithm of *On-Site Pollution* by establishment j of firm i in year t. $Treat^i_{j,c}$ is a binary indicator that equals one if establishment j of firm i in cohort c experiences the first-time designation of a protected area within a 30-km radius in year 0. $Post_{c,t}$ equals one for years on or after the designation year within cohort c and zero otherwise. $\delta_{j,c}$ captures establishment-cohort fixed effects, controlling for time-invariant unobserved differences within a cohort. $\varphi_{ind,t,c}$ represents industry-year-cohort fixed effects, accounting for time-varying industry-wide shocks that affect all establishments in the same cohort. Finally, $\delta_{state,t,c}$ controls for state-specific heterogeneities over time.

4. Empirical Results

4.1 Biodiversity Conservation Exposure and On-site Toxic Releases

Protected areas are legally or effectively designated regions aimed at ensuring long-term nature conservation. Given their environmental significance, production sites near these

[15] Establishments with zero reported on-site pollution throughout the estimation window are removed from the analysis. However, our conclusion remains unaffected even when these observations are included.

areas often face stricter regulations and heightened public scrutiny, increasing firms' exposure to biodiversity-related risks. This raises the question of whether firms proactively mitigate these risks by reducing toxic emissions. To test this, we examine whether U.S. establishments with greater exposure to protected areas, measured by our CBE metric, show a discernible decrease in toxic releases from production plants.

We address our central research question by estimating the relationship between on-site toxic releases and CBE, measured within a 30-km radius of protected areas, as specified in Eq. (1). Table **2** presents the regression results. We find consistently negative and statistically significant coefficients for CBE across all columns, indicating a robust relationship between protected area exposure and pollution reduction. Column (1) estimates a simple univariate regression of the natural logarithm of *On-Site Pollution* on CBE, without control variables or fixed effects, yielding a coefficient of -0.006 (t-value = -7.22). While this model provides an initial estimate of the relationship between protected area exposure and toxic emissions, it does not account for potential confounding factors. To address this, the model is progressively refined by incorporating additional controls and fixed effects.

Column (2) introduces control variables to account for observable establishment and firm characteristics that may influence pollution levels. Column (3) strengthens the model further by adding establishment and year fixed effects, which control for time-invariant differences across establishments and macro trends in pollution over time. To account for industry-specific factors, Column (4) incorporates industry-year fixed effects, ensuring that the estimated effect of CBE is not driven by pollution trends in industries with severe environmental impact (e.g., mining and manufacturing) or those heavily dependent on natural ecosystem services (e.g., agriculture and forestry). Finally, Column (5) introduces state-year fixed effects to control for regional variations in economic and environmental policies, which may influence both protected area enforcement and pollution regulation (Di Giuli and Kostovetsky 2014; Baldauf, Garlappi, and Yannelis 2020).

Regardless of the fixed effects specification, the coefficient estimates of CBE range from -0.008 to -0.004 and remain statistically significant. The consistent economic magnitude across columns indicates a persistent firm response to protected area designations, independent of firm size, industry, or geographic region.[16] Notably, the impact of CBE is also

[16]The number of observations varies across different model specifications due to the exclusion of singleton

economically significant. Based on Column (5), which includes the most conservative fixed effects, a one-standard-deviation increase in CBE corresponds to a 31% (=$e^{-0.008\times46.31}$-1) reduction in *On-Site Pollution*, highlighting the substantial role of biodiversity conservation exposure in shaping corporate environmental behavior.

[Insert Table **2** Here]

4.2 Additional Identification Tests

To reinforce our baseline findings, we conduct three additional identification tests, presented in Table **3**. The first test employs a stacked event study DiD analysis, focusing on the first-time designation of a protected area within a 30-km radius of an establishment, as specified in Eq. (2). This analysis spans from four years before to four years after the designation event, allowing us to examine the dynamic effects of new protected areas on nearby firms' behavior. In this DiD framework, the treatment group consists of establishments that experience a first-time protected area designation during the sample period. To construct the control group, we select establishments in the same states that did not experience any protected area designations, ensuring that comparisons account for state-level differences in environmental enforcement. The results, reported in Column (1) of Table **3**, show that the coefficient estimate for the $Treat \times Post$ interaction term is negative and statistically significant, indicating a substantial reduction in toxic emissions following protected area designations. Compared to control establishments within the same states, treatment establishments exhibit a more than 50% reduction in toxic emissions, highlighting the strong environmental impact of biodiversity conservation policies on corporate pollution behavior.

The key identifying assumption in the DiD analysis is that treated and control establishments exhibit no differential trends in toxic emissions prior to treatment. However, like many environmental policies, protected area designations may be anticipated by nearby facilities, potentially introducing a downward bias in the estimated treatment effect. Specifically, firms may strategically locate away from habitats and green spaces likely to be designated as protected areas or preemptively reduce pollution in anticipation of regulatory changes. Despite

observations in the fixed effects regressions.

this possibility, anticipatory effects are less likely in our setting because we focus on economic activities outside protected areas, which are only indirectly affected by protected area policies (Frank et al. 2025). To formally test for such effects, we replace the *Post* dummy with nine time dummies, each representing a period relative to the designation year. The dummy for t = -1 (one year before the event) is omitted as the benchmark for comparison.

The estimation results, reported in Column (2) of Table **3** and visualized in Figure 3, show no statistically significant differences in toxic pollution between treated and control establishments in the pre-treatment years. This suggests that the parallel trends assumption holds, confirming that the observed pollution reductions are attributable to protected area designations rather than pre-existing trends. The intertemporal shift in toxic pollution further reinforces the notion that new environmental regulations and heightened scrutiny from designations prompt establishments to adjust their practices and comply with stricter environmental standards.

The second identification test is a falsification test, where we use off-site toxic releases (*Off-Site Pollution*) as a placebo for on-site toxic releases. Unlike on-site toxic releases, which occurs at the facility and is subject to direct regulatory oversight, off-site toxic releases is typically released farther from protected areas, making it less likely to be affected by the same environmental restrictions. To test this, we re-estimate Eq. (2) using *Off-Site Pollution* as the dependent variable. The results, presented in Column (3) of Table **3**, show that the coefficient for the $Treat \times Post$ interaction term is statistically insignificant. In contrast to the strong effects observed on on-site toxic releases, this finding suggests that protected area designations do not influence off-site emissions, substantiating the validity of our main results.

The third identification test investigates whether the observed CBE effect diminishes or reverses following the relaxation or removal of protected area enforcement. Local and federal governments may alter a protected area's legal status through a process known as Protected Area Downgrading, Downsizing, and Degazettement (PADDD), which includes three key actions: (1) Downgrading – easing restrictions on the scope or intensity of human activities within the protected area. (2) Downsizing – reducing the geographic boundaries of the protected area. (3) Degazettement – completely revoking the protected area's legal protections. Although protected areas play a crucial role in biodiversity conservation, these legal modifications can disrupt ecosystems, threaten species, and affect local communities dependent on natural resources.[17]

To conduct this test, we rely on PADDDtracker.org, a peer-reviewed database maintained by Conservation International and the World Wildlife Fund, which tracks PADDD events and analyzes their implications for conservation science and policy. According to this dataset, 61% of enacted PADDD events globally are linked to industrial-scale resource extraction and development, including infrastructure projects, industrial agriculture, oil and gas operations, and mining (Golden Kroner et al. 2019). A notable example is the 2017 downsizing of Bears Ears National Monument by 4,657 square kilometers (85%), allowing for mining exploration activities.[18] In the U.S., 1,189 proposed and enacted PADDD events have been documented, affecting 522 protected areas.[19] PADDDtracker.org provides World Database on Protected Areas (WDPA) identifiers for these sites, which we use to link PADDD-affected areas to production facilities in our sample. To enhance the accuracy of this linkage, we apply fuzzy name matching, supplemented by manual verification, to align affected area names with our dataset. Through this process, we identify 90 officially enacted PADDD events affecting 90 protected areas within our sample.

This dataset allows us to empirically assess whether firms increase pollution following the weakening of protected area governance. Using this matched dataset, we define the treatment group as facilities located within a 30-km radius of the 90 protected areas that have experienced weakened governance. The control group consists of facilities outside these protected areas but within the same states, ensuring that comparisons account for state-level economic and regulatory conditions. Contrary to the expected reversal effect, the coefficient for $Treat \times Post$ in Column (4) is statistically insignificant, suggesting that the relaxation of protected area governance does not lead to a resurgence in pollution. This finding provides an important policy insight: protected area designations may induce long-term structural shifts in local economies and demographics. Even when governance is weakened, firms may continue to comply with prior environmental standards, suggesting that protected area en-

[17] Such retractions weaken environmental protections due to local development policies and land-use pressures (Börner et al. 2020).

[18] See Mascia and Pailler (2011) for an in-depth analysis of PADDD events.

[19] Conservation International & World Wildlife Fund. (2021). PADDDtracker Data Release Version 2.1 (2.1) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.4974336.

forcement can have enduring effects on corporate behavior, potentially reducing reliance on ongoing regulatory oversight.

[Insert Table **3** Here]

4.3 Economic Mechanisms

In the next step, we investigate the economic mechanisms driving the reduction in toxic emissions following the establishment of protected areas near industrial facilities. Specifically, we examine two potential channels: (1) a decline in economic activity and (2) increased investment in pollution abatement technologies. Understanding which mechanism dominates is crucial for assessing the broader economic implications of biodiversity conservation policies.

The first mechanism operates through higher compliance costs as industrial facilities must adhere to stricter environmental regulations following protected area designations. In addition to direct regulatory constraints, firms face greater reputational risks, as local communities and government agencies intensify scrutiny of their environmental impact. This increased oversight may lead to greater enforcement of pollution limits, discouraging firms from maintaining high emission levels. Beyond regulatory compliance, economic activity may also decline due to expanded land protections. These protections limit access to natural resources or restrict industrial operations, particularly in industries that exert environmental pressures or depend on ecosystem services. Zafra-Calvo et al. (2019) find that local stakeholders often perceive a loss of rights over natural resources after protected area designations, which may discourage firms from maintaining pre-designation production levels.

Alternatively, rather than scaling down operations, some firms comply with stricter environmental standards by investing in pollution control technologies. This second mechanism arises from regulatory-mandated technological upgrades and sustainability-driven investments. Industrial facilities operating near protected areas may be required to adopt Best Available Control Technology (BACT) or implement pollution abatement measures as part of compliance with environmental regulations (e.g., the EPA's Prevention of Significant Deterioration program). These regulations often compel firms to modernize production processes, invest in cleaner technologies, or transition to more sustainable business practices, all of which contribute to long-term reductions in toxic emissions.

To empirically distinguish between these mechanisms, we analyze changes in economic activity at the establishment level. We focus on three key measures: $Sales$ (the natural logarithm of inflation-adjusted sales), $Productivity$ (the natural logarithm of one plus the ratio of inflation-adjusted sales to the number of employees), and $Workforce$ (the total number of employees at an establishment). These metrics capture potential shifts in revenue, operational efficiency, and employment in response to protected area designations. The regressions include the same control variables used in Eq. (1), except that $Ln(Workforce)$ is excluded when employment is the dependent variable. Summary statistics for these additional facility-level variables are reported in Online Appendix Table OA2. Table 4 presents the regression results.

[Insert Table 4 Here]

In Column (1), we examine the association between establishment sales and CBE. The results indicate a statistically significant and negative coefficient at the 5% level, with a one-standard-deviation increase in CBE leading to a 4.5% (=$e^{-0.001\times 46.31}$-1) decline in sales relative to the sample mean. This suggests that higher biodiversity risk modestly but measurably impacts sales performance, likely due to increased regulatory constraints. In Column (2), we examine the effect of CBE on productivity. Similar to sales, the coefficient remains statistically significant and negative, indicating that a one-standard-deviation increase in CBE is associated with a decline in productivity of a similar magnitude. This finding highlights the operational challenges firms may face as public governance over surrounding protected areas intensifies, potentially limiting resource access or imposing stricter compliance requirements. Finally, in Column (3), we assess the impact of CBE on workforce size using the PPML estimator, which accommodates the skewness and non-negative nature of count variables such as employment data. Once again, the CBE coefficient is negative and statistically significant at the 10% level, suggesting employment losses as firms scale down operations in response to increased biodiversity risk. Taken together, these findings suggest that protected area designations impose operational constraints through land-use restrictions and increased public governance, prompting businesses to reduce production scale, lower productivity, and cut local employment.

Next, we investigate whether the reduction in emissions stems from increased investment in abatement technologies, using data from the EPA P2 database. If firms respond to new protected area designations by adopting cleaner technologies, we would expect to see a rise in pollution abatement investments. To test this, we first analyze overall abatement investment, measured by the *Abatement* variable, which captures the number of polluting source reduction activities at a facility in a given year. We then classify pollution abatement activities into three categories: (1) Operation-related abatement – measures aimed at improving operational efficiency; (2) Process-related abatement – modifications to production processes to reduce emissions; and (3) Other abatement – changes to materials, product designs, or inventory management.[20] Since all abatement-related variables are count-based, we use the PPML estimator for this set of tests. Table **5** presents the results, showing that the coefficient estimate of CBE is statistically insignificant at all conventional significance levels when overall abatement investment is the dependent variable (Column (1)). Furthermore, when disaggregating abatement into its three categories, we find no significant relationship between CBE and any type of abatement investment (Columns (2)-(4)).[21]

Collectively, these results suggest that firms primarily reduce emissions by scaling down economic activity rather than investing in abatement technologies. This finding aligns with policy concerns regarding the economic repercussions of protected area designations, where regulatory constraints may discourage production rather than incentivize technological adaptation (Zafra-Calvo et al. 2019; Grupp et al. 2023).

Our findings offer a useful comparison with prior research in climate finance (e.g., Addoum, Ng, and Ortiz-Bobea 2020), which finds that climate-related risks, such as temperature shocks, have a small positive but statistically insignificant impact on establishment-level operating performance. Several factors may explain why biodiversity shocks exert a more pronounced impact. First, temperature shocks are typically short-lived and may not imme-

[20]EPA reports five different forms of abatement investment: (1) changes in operating practices and training, (2) process and equipment improvements, (3) material substitutions and modifications, (4) product modifications, and (5) inventory and material management. However, Akey and Appel (2021) note that the first two abatement investments relating to operational changes and process improvements are the most common types. As such, we group the latter three forms into one category as "other modifications".

[21]In untabulated results, we also include total toxic releases as an additional control variable given the strong positive correlation between abatement investment and toxic emissions but the results are qualitatively unaffected.

diately disrupt business operations, particularly in industries with built-in climate resilience. Yet, biodiversity shocks often signal long-term environmental degradation, affecting supply chains, resource availability, and land use, which directly constrains productivity and sales. Second, temperature shocks tend to affect large geographic areas uniformly, allowing firms to adapt using air conditioning, irrigation, or infrastructure reinforcements. But biodiversity shocks are highly localized, particularly in areas near protected zones, where land-use restrictions, regulatory constraints, and conservation mandates impose direct operational limitations on firms. Finally, protected area designations are deliberate policy interventions aimed at addressing biodiversity loss, often introducing compliance costs and operational constraints for affected firms. In contrast, temperature shocks rarely lead to immediate regulatory responses, allowing firms to maintain stable operations. Furthermore, our findings underscore a distinct form of environmental liability associated with biodiversity risk, which differs from the general liabilities of toxic emissions. While Akey and Appel (2021) find that the general environmental liabilities of parent companies affect their facilities' toxic pollution through investments in abatement technologies rather than firms' long-term production, biodiversity risk tied to protected areas has a more enduring impact on firms' economic activities, reshaping their long-term operational and financial outlook.

[Insert Table **5** Here]

4.4 Spillover Effects of Protected Areas on Corporate Financial Performance

Building on the financial impact of protected area designations on industrial facilities, a key question emerges: Do these effects extend to their parent companies? Examining this spillover is crucial for advancing biodiversity finance research, as it reveals how firm exposure to conservation policies translates into financial market outcomes. By identifying the channels through which biodiversity conservation influences asset prices, this analysis offers deeper insight into the broader economic implications of protected area policies and associated land-use restrictions.

To address this question, we estimate a modified version of Eq. (1) at the parent-firm level.

In this specification, CBE is redefined as the aggregate number of protected areas within a 30-km radius of all production facilities owned by the parent company.[22] This adjustment captures the cumulative exposure of a firm's entire operational network to biodiversity conservation policies. To assess the cash flow implications of protected area designations for parent companies, we examine three key financial indicators, mirroring the establishment-level analysis: (1) ROA, defined as earnings before interest, taxes, depreciation, and amortization scaled by lagged total assets, (2) $Productivity$, measured as the natural logarithm of one plus the ratio of firm sales to the number of employees, and (3) TFP (Total Factor Productivity), estimated as the residual from the log-transformed Cobb-Douglas production function.[23] Table **6** reports the parent-firm level results. Consistent with the facility-level analysis, we find significant financial consequences for parent companies with facilities exposed to protected area designations. The coefficients for firm-level CBE are statistically significant and negative across all three financial indicators, with significance levels of at least 5% in Columns (1)–(3). These findings suggest that the economic constraints imposed by conservation policies at the facility level extend to corporate financial performance, reinforcing the broader implications of biodiversity risk for firms operating near regulated areas.

Given the consistently strong impact of protected area designations on parent companies' financial performance, we extend our analysis to assess their effect on stock market valuation. Stock market valuation is proxied by *Tobin's Q*, defined as (the book value of total assets minus the book value of common equity plus market capitalization) divided by total assets. In Column (4), we find a negative and statistically significant coefficient for parent firm-level CBE, indicating that greater exposure to protected areas is associated with lower market valuations. A one-standard-deviation increase in firm-level CBE corresponds to a 1.3% (=1.498 $\times$ 0.014/1.642) decline in *Tobin's Q* relative to its sample mean. While modest, this finding reinforces the financial materiality of biodiversity risk, demonstrating that exposure to designated protected areas affects firms not only through cash flow constraints but also via equity prices. These results highlight the importance of incorporating biodiversity risk

[22] The variable is scaled by 100 for the regressions reported in Table **6** to enhance the interpretability of the estimated coefficients, specifically with respect to their economic significance.

[23] Following prior studies (e.g., Faleye, Mehrotra, and Morck 2006; Bennett, Stulz, and Wang 2020), we estimate the log-transformed Cobb-Douglas production function $Y_{i,t}$=$AL^{\beta}_{i,t}K^{\alpha}_{i,t}$ for each two-digit NAICS industry-year with at least 30 observations in our sample. For each firm i in year t, net sales represent output (Y), employee count represents labor (L), and net plant, property, and equipment represent capital (K).

into corporate valuation models and investment strategies.

[Insert Table 6 Here]

4.5 Regulatory Risk and the Impact of Biodiversity Protection

The empirical findings from the preceding tests suggest that industrial facilities face heightened regulatory risks following the designation of nearby protected areas. These risks may arise from increased scrutiny by governing authorities or greater local community awareness of the environmental impact of industrial activities. In particular, communities may become more proactive in reporting pollution concerns to regulatory agencies, potentially leading to stricter enforcement actions. To explore regulatory risk as a key driver of our main findings, this section conducts a series of tests to examine the direct link between protected area designations and the environmental regulatory pressures imposed on businesses.

We employ five distinct proxies to measure environmental regulatory risk at the facility level: (1) Environmental enforcement indicator ($Enforcement$) – a binary variable indicating whether a facility has been subject to an enforcement action for environmental violations; (2) Number of enforcement actions (*Enforcement Count*) – the total number of environmental enforcement actions initiated against a facility; (3) Monetary penalties ($Ln(Penalties)$) – the natural logarithm of fines imposed due to environmental enforcement actions; (4) Inspection indicator ($Inspection$) – a binary variable indicating whether a facility has been inspected by environmental regulatory agencies; and (5) Number of inspections (*Inspection Count*) – the total number of regulatory inspections conducted at a facility. All these variables are sourced from the ICIS FE&C database. Since *Enforcement Count* and *Inspection Count* are count variables, we apply the PPML estimator for these regressions. Environmental enforcement actions are relatively rare in our sample, affecting only 5.26% (=8,707/165,500) of observed facility-years. To ensure comparability between facilities with and without enforcement actions, we implement propensity score matching. Each treated facility (i.e., one subject to enforcement) is matched to its closest control counterpart located within the same state during the enforcement year, using observable parent-firm-level covariates as specified in Eq. (1). We then conduct our regulatory risk analysis using this matched sample.

Consistent with the heightened regulatory risk linked to protected area designations, Column (1) of Table 7 shows a significantly positive coefficient for *CBE*, indicating that facilities near designated protected areas face a higher likelihood of environmental enforcement. Further, Columns (2) and (3) reveal that both the number of enforcement actions and the financial penalties imposed increase significantly with CBE, reinforcing the regulatory burden faced by affected facilities. However, given the restricted sample size, these findings may not fully generalize to all firms in the dataset. To address this concern, we incorporate regulatory inspections as alternative proxies for regulatory risk in the full sample, reported in the last two columns of Table 7. In Column (4), the coefficient for CBE is negative but statistically insignificant when using the $Inspection$ dummy as the dependent variable. However, in Column (5), CBE is positively associated with the number of inspections, attaining statistical significance at the 10% level. Taken together, the results in Table 7 provide consistent evidence that facilities near newly designated protected areas face increased regulatory scrutiny, particularly in the form of enforcement actions, penalties, and inspections, underscoring the regulatory risks tied to biodiversity conservation policies.[24]

[Insert Table 7 Here]

Expanding on our earlier results, we examine whether the effect of CBE on on-site toxic release depends on a facility's environmental regulatory risk. To test this, we augment the baseline model (Eq. (1)) by introducing interaction terms between CBE and each of the five regulatory risk proxies analyzed in Table 7. If pollution reduction occurs primarily through increased regulatory scrutiny, we expect the CBE effect to be more pronounced for facilities facing higher regulatory risk. Since environmental enforcement actions are relatively rare, we again rely on the matched sample from Table 7 for any regressions involving enforcement-related variables, ensuring a robust comparison between facilities subject to enforcement actions and their matched counterparts. Table 8 presents the results. In Columns (1)-(3), the interaction terms between CBE and $Enforcement$, *Enforcement Count*, and *Ln(Penalties)*

[24]In Online Appendix Table OA3, we re-estimate all regression models in Table 7 with an additional control for an establishment's previous-year pollution level. These robustness checks address the concerns that increased enforcement or inspection activities may be attributable to greater levels of toxic emissions, rather than the designation of protected areas. Our primary conclusions remain unaffected with this additional control variable.

all yield consistently negative and statistically significant coefficients. These findings indicate that facilities subjected to more frequent enforcement actions or higher penalty amounts experience the largest reductions in *On-Site Pollution*, reinforcing the role of regulatory enforcement as a key driver of pollution abatement. Turning to regulatory inspections, we analyze their marginal effects in the full sample in Columns (4)-(5). Here, we find no significant coefficients for the interaction terms, while the main effect of CBE remains significant and negative. This evidence suggests that while formal enforcement actions (e.g., fines and penalties) drive pollution reductions, routine regulatory inspections alone do not exert the same impact.

To further substantiate the regulatory risk explanation, we examine whether the effect of CBE on pollution varies based on a facility's or its parent firm's exposure to environmental regulatory scrutiny. At the facility level, we differentiate protected areas by their governing authorities, under the premise that firms face greater regulatory risk when protected areas are managed by government agencies. To capture this distinction, we decompose CBE into two mutually exclusive variables: (1) $CBE_{\textit{Gov Exposed}}$ – the number of protected areas within a 30-km radius of a facility if at least one of these protected areas is governed by federal or state authorities and zero otherwise, and (2) $CBE_{\textit{Non-Gov Exposed}}$ – the number of protected areas within a 30-km radius if none of these protected areas is governed by federal or state agencies and zero otherwise. Column (6) shows that the pollution-reducing effect of CBE is concentrated in facilities near protected areas managed by government agencies, highlighting the role of formal regulatory oversight.

At the parent-firm level, we measure corporate exposure to environmental regulatory bodies using a text-based *Government Exposure* metric,[25] developed by Armstrong, Glaeser, and Hoopes (2024). This measure, derived from 10-K filings, quantifies a firm's regulatory interactions and oversight intensity. In Column (7), we find a significantly negative coefficient for $CBE \times$ *Government Exposure*, further supporting the regulatory risk effect. Together, these results provide strong evidence that heightened regulatory biodiversity risk is the primary driver of pollution reductions following protected area designations.

[25] The federal environmental regulatory bodies include: Agency for Toxic Substances and Disease Registry, Department of Agriculture, Department of Energy, Environmental Protection Agency, Fish and Wildlife Service, U.S. Forest Service, U.S. Geological Survey, National Oceanic and Atmospheric Administration, National Weather Service, and Natural Resources Conservation Service.

[Insert Table 8 Here]

5. Cross-Sectional Insights and Robustness Analysis

In this section, we conduct cross-sectional analyses and robustness tests to further validate our main findings. The cross-sectional analysis examines heterogeneity in observable firm characteristics that may influence the effectiveness of nature conservation efforts, while the robustness tests ensure the consistency of our results across alternative model specifications and CBE measures.

5.1 Cross-sectional Analysis

In the first cross-sectional test, we examine whether the pollution-reducing effect of CBE varies between large and small polluters. Facilities with higher toxic emissions exert greater pressure on natural ecosystems, making them more likely to experience heightened regulatory scrutiny following the designation of a new protected area. To test this hypothesis, we introduce $Polluter$, a dummy variable that equals one if a facility's *On-Site Pollution* exceeds the sample median in the previous year and zero otherwise. This classification allows us to assess whether facilities with greater pre-existing pollution levels face disproportionate regulatory pressure in response to biodiversity conservation measures. Column (1) of Table 9 reports the results. The coefficient for $CBE \times Polluter$ is negative and marginally significant, while the main effect of CBE remains significant at the 5% level. These findings align with the expectation that heavy polluters experience intensified regulatory enforcement when operating near newly designated protected areas, consistent with the role of regulatory risk in pollution reductions.

Prior research (Bartram, Hou, and Kim, 2022; Xu and Kim, 2022) highlights that financial constraints may limit firms' ability to invest in activities aimed at reducing environmental externalities. Motivated by this insight, we investigate whether parent firms' financial constraints influence the ability of their establishments to reduce pollution following protected area designations. Specifically, we classify financially constrained firms using the sample median of the Kaplan and Zingales (1997) index, calculated based on parent firms' financial condition and liquidity. In Column (2), the coefficient for the interaction term, $CBE \times$ *Financial Constraints*, is negative and marginally significant, indicating that financially constrained parent companies experience greater difficulty reducing emissions at their facilities.

In our final cross-sectional analysis, we examine biodiversity risk exposure across industries. Specifically, we assess a facility's impact and dependence on natural ecosystem services using the ENCORE database. ENCORE integrates sector-specific research and expert interviews across 271 economic activities classified under the International Standard Industrial Classification (ISIC) to quantify each activity's dependence on and economic pressure exerted upon 25 ecosystem services. As of October 2024, ENCORE provides static pressure and dependency materiality ratings, ranging from Very Low (coded as 2) to Very High (coded as 6) for each ISIC code. We incorporate these ratings into our facility-level data by mapping ISIC to six-digit NAICS codes and computing the average pressure and dependency scores across the 25 ecosystem services for each sector. Using these scores, we define two dummy variables, *Impact* and *Dependence*, identifying facilities whose industries have above-median pressure or dependency materiality scores, respectively.[26]

The regression results in the final two columns of Table 9 show that the interaction coefficients between CBE and $Impact$ and between CBE and $Dependence$ are statistically insignificant. These findings suggest that pollution reductions triggered by protected area designations are not confined to traditionally biodiversity-sensitive industries but occur broadly across various sectors. Given that firms interact with and rely on natural resources at different stages of production, we caution that facility-level industry classifications alone may not fully capture their exposure and sensitivity to biodiversity risks near protected areas.

[Insert Table 9 Here]

[26] Online Appendix Table OA4 lists the top 10 industries in our sample exerting the highest pressure on or reliance upon ecosystem components, with most belonging to the agriculture or mining sectors.

5.2 Robustness Tests

This section extends our baseline analysis by conducting additional robustness checks to ensure the reliability of our findings under alternative econometric methods and measurements. The corresponding results are reported in Table **10**. First, while our primary analyses employ OLS regressions with the dependent variable measured as the natural logarithm of on-site toxic emissions, the underlying emission data are nonnegative and exhibit right-skewness. To confirm that our findings are robust to this distributional issue, we re-estimate Eq. (1) using the raw emission values as the dependent variable and employing the PPML estimator. Column (1) of Table **10** reports the results, showing a negative and statistically significant coefficient for CBE, consistent with our baseline estimates. This indicates that our primary findings are robust to alternative estimation methodologies and are not sensitive to the specific functional form chosen for our dependent variable.

The relationship between CBE and facility-level pollution may not necessarily be linear. It is plausible that establishments respond differently depending on specific features of the protected areas, such as their size, ecological significance, or the economic prominence of the facilities themselves to their parent companies and local economies. For example, facilities may reduce emissions more significantly when located near larger or more ecologically important protected areas. Similarly, facilities contributing a greater share of their parent firm's revenue or employing a larger fraction of its workforce may adjust emissions differently. To address these possibilities and ensure our findings are robust, we re-estimate Eq. (1) using the four alternative CBE metrics introduced in Section 3.1. Columns (2)-(6) of Table **10** report the results from these alternative measures. Across all specifications, we consistently find a significant negative relationship between protected area exposure (CBE) and on-site toxic emissions, confirming that our primary results are robust to alternative definitions of biodiversity exposure and further supporting the reliability of our conclusions.

[Insert Table **10** here]

6. Concluding Remarks

Our analysis provides robust evidence that corporate biodiversity exposure, measured by proximity to protected areas, significantly reduces toxic emissions from industrial facilities. By establishing a clear connection between facility locations and their environmental performance, our biodiversity exposure measure highlights the tangible impact of nature conservation policies. Importantly, we find that firms primarily respond to new protected area designations by scaling back economic production rather than investing proactively in pollution-control technologies. Further investigation reveals regulatory risk as the key driver behind these reductions, demonstrating a direct relationship between proximity to protected areas and increased regulatory scrutiny. Collectively, these findings underscore the economic trade-offs inherent in biodiversity protection and clarify the mechanisms through which conservation policies influence corporate environmental behavior.

Our corporate biodiversity exposure metric aligns closely with best practices employed by policymakers, investors, and third-party data providers to assess biodiversity-related risks. Given the ambitious '30 by 30' conservation target established at COP15, our findings offer timely and actionable insights with meaningful implications for both policy and business strategies. Policymakers can utilize these insights to strike a balance between achieving ecological goals and managing their associated economic impacts, thereby facilitating effective biodiversity conservation planning and promoting transparency in corporate biodiversity disclosures. Companies, in turn, can strategically integrate biodiversity risk assessments into their operational and location decisions, proactively aligning their business practices with evolving conservation priorities. For investors, recognizing regulatory risks stemming from proximity to protected areas is particularly critical, given the significant cash flow implications highlighted by our analysis. By incorporating biodiversity exposure into investment decisions, financial market participants can better anticipate potential valuation effects and more accurately assess long-term investment risks.

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Figure 1. The Geography of Protected Areas in the United States

The plot shows protected areas in the contiguous United States, excluding Hawaii and Alaska. The x and y axes represent the longitude and latitude coordinates of these areas. The data is sourced from the World Database on Protected Areas. Areas marked in light green denote those designated before 1989, while those marked in dark green denote areas designated in 1990—the start of our sample period.

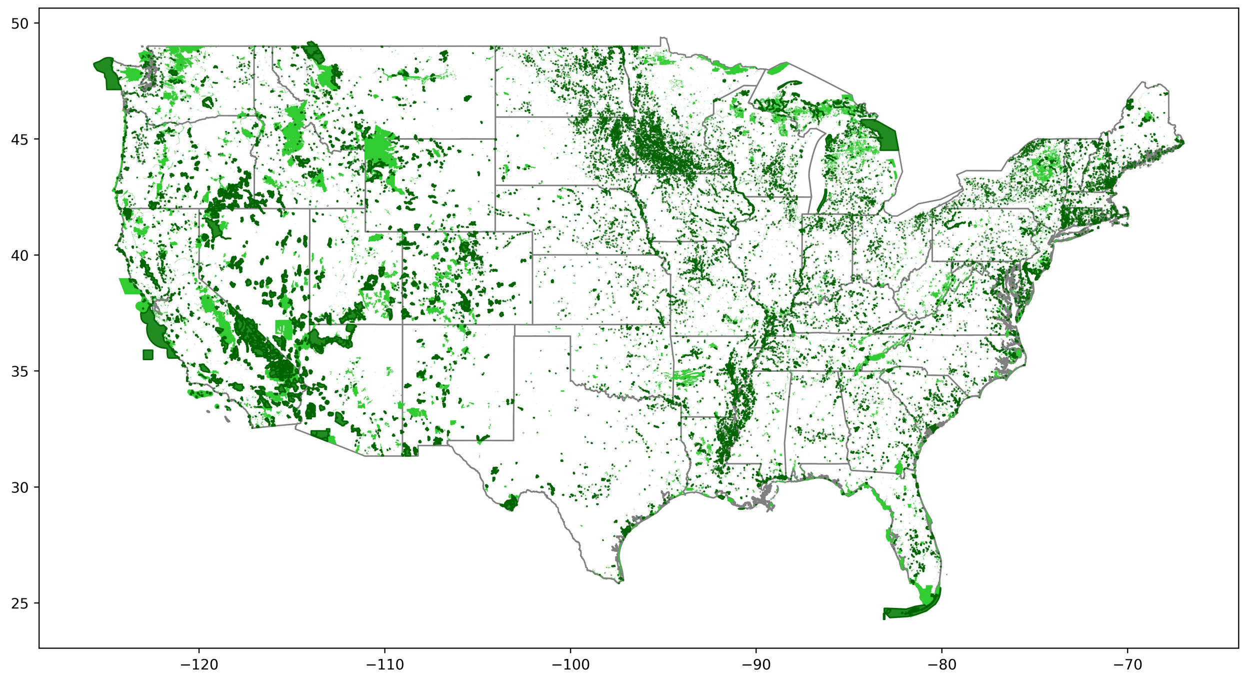

Figure 2. Eastman Chemical Company's Production Establishment

The plot illustrates our Corporate Biodiversity Exposure (CBE) measure using a production establishment of Eastman Chemical Company (TRIFD:37662TNNSSEASTM), marked with a blue dot. The 10, 30, and 50-kilometer buffer zones around this establishment are indicated in orange, while protected areas in its vicinity are marked in green. The CBE measure counts the number of protected areas that overlap with these buffer zones.

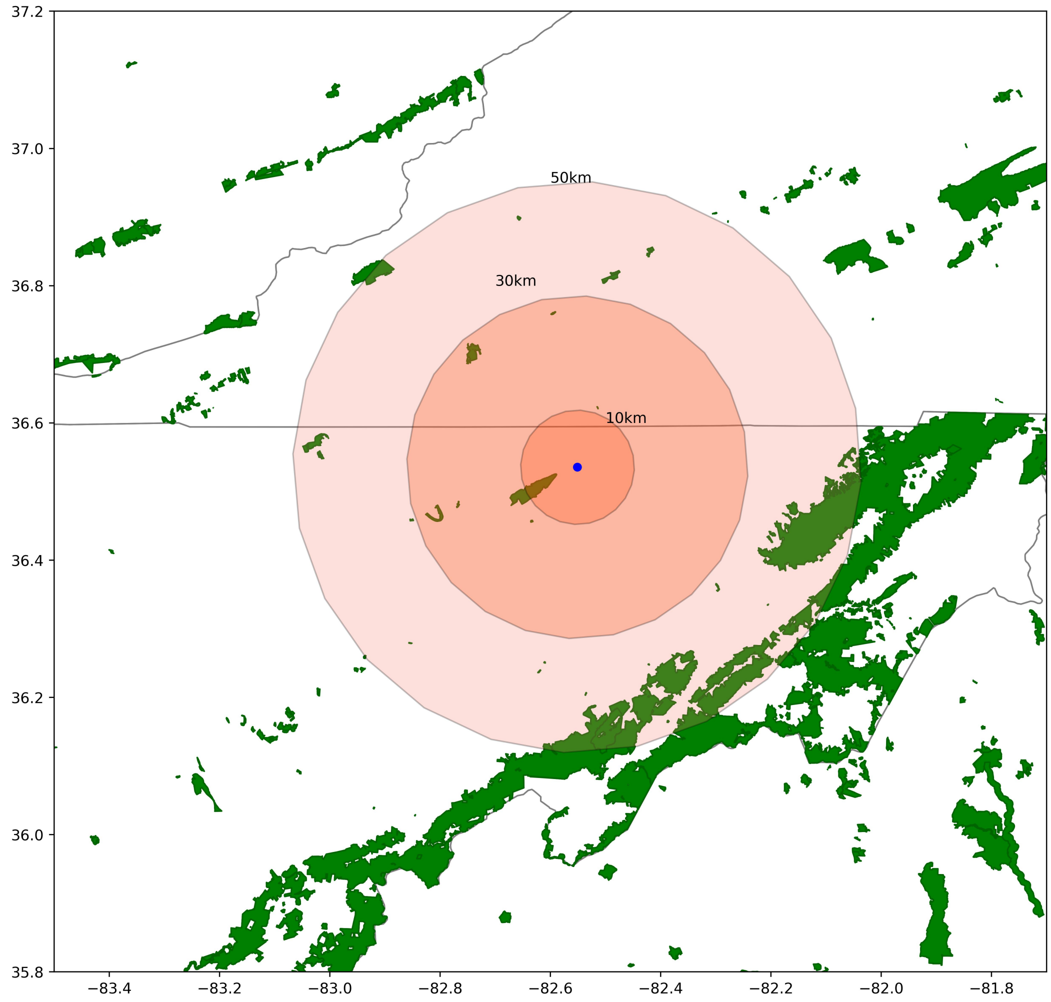

Figure 3. Dynamic Effects of First-Time Protected Area Designation on On-Site Pollution

This figure displays the dynamic effects of first-time protected area designation on establishment-level *Ln(On-Site Pollution)*. To estimate the dynamic effects, we replace $Treat \times Post$ indicator in our stacked DiD regression with interaction terms between the $Treat$ indicator and event year indicators from $t-4$ to $t+4$ around the event year t, taking event year $t-1$ as our reference group. In this figure, we plot the estimated interaction coefficients and their associated 90% confidence interval.

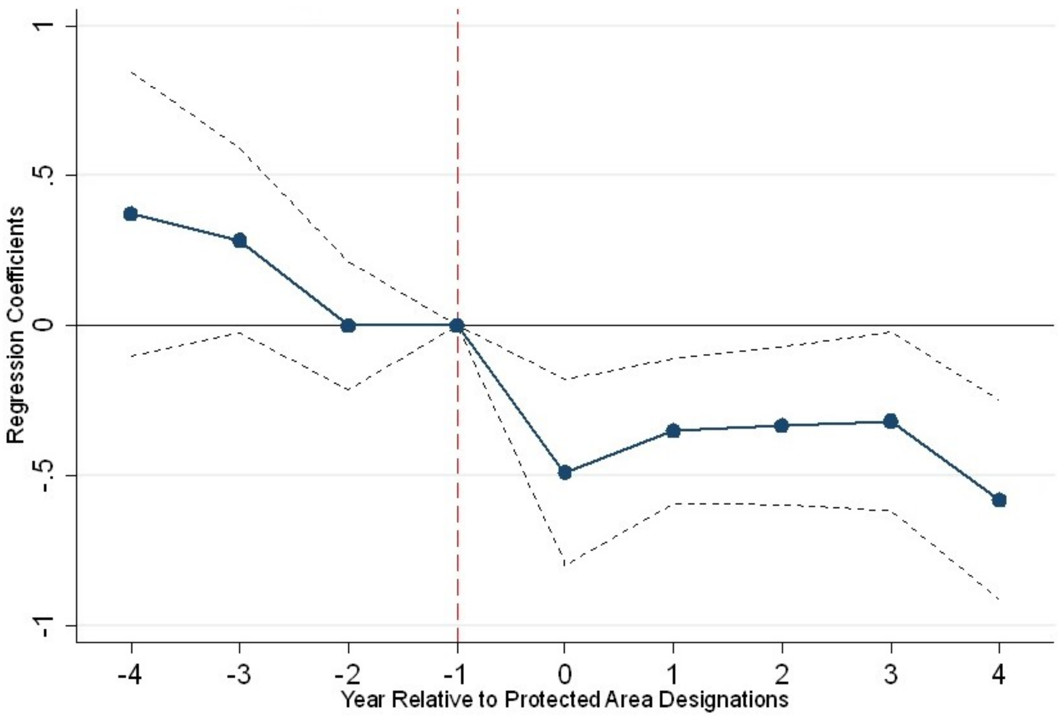

Table 1. Summary Statistics

This table presents the summary statistics (i.e., Mean, Standard Deviation (SD), median (50%) as well as 25% and 75% percentiles) of the variables used in our baseline regression models. All variables are measured annually. *On-Site Pollution* is the amount of on-site toxic chemical releases (in pounds) into the air, ground, and water by an establishment in a given year. *CBE* is the biodiversity conservation exposure, defined as the number of protected areas within a 30-km radius from an establishment's location in the previous year. *Workforce* is the number of an establishment's employees. *Size* is the natural logarithm of the parent firm's market capitalization, while *Tobin's Q* is defined as the parent firm's total assets minus its book value of common equity plus market capitalization, divided by total assets. *Leverage* is the sum of long-term debt and debt in current liabilities scaled by the book value of total assets. *Cash* is the ratio of cash and short-term investments to total assets. *CAPEX* is capital expenditure divided by prior-year total assets. *Tangibility* is the value of net property, plant, and equipment scaled by prior-year total assets. *Profitability* is earnings before interest and taxes scaled by total sales. Both *CBE* and the parent-firm-level controls are lagged by one year. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The sample period spans from 1990 to 2021.

Variable	Observations	Mean	SD	25%	50%	75%
Establishment-level characteristics						
CBE	165,500	13.52	46.31	2.000	5.000	10.000
On-Site Pollution	165,500	130,205	486,333	1.000	1,089	27,918
Ln(On-Site Pollution)	165,500	6.291	4.741	0.693	6.994	10.24
Workforce	165,500	353.9	782.6	51.00	150.0	366.0
Ln(Workforce)	165,500	4.872	1.540	3.932	5.011	5.903
Parent-firm-level characteristics						
Size	165,500	8.184	2.140	6.872	8.257	9.677
Tobin's Q	165,500	1.579	0.654	1.145	1.385	1.803
Leverage	165,500	0.293	0.154	0.188	0.279	0.385
Cash	165,500	0.069	0.073	0.016	0.044	0.098
CAPEX	165,500	0.053	0.037	0.027	0.044	0.069
Tangibility	165,500	0.349	0.193	0.204	0.310	0.456
Profitability	165,500	0.101	0.068	0.057	0.093	0.137

Table 2. Effects of Biodiversity Exposure on Establishment On-Site Pollution

This table presents the estimation results of our baseline continuous treatment intensity DiD regression model:

$$\begin{aligned} \textit{Ln(On-Site Pollution}^i_{j,t}) &= \alpha_0 + \beta_1 CBE^i_{j,t-1} + \beta_2 Ln(Workforce^i_{j,t}) + \Lambda' X^i_{t-1} \\ &\quad + \gamma_j + \varphi_{ind,t} + \delta_{state,t} + \epsilon^i_{j,t} \end{aligned}$$

where i, j, ind, $state$ and t denote parent firm, establishment, industry, state and year, respectively. *Ln(On-Site Pollution)* is the natural log of total on-site toxic chemical releases (in pounds) into the air, ground, and water by firm i's establishment j in year t. *CBE* is our location-based corporate biodiversity exposure measure, defined as the number of protected areas within a 30-kilometer radius of establishment j's location in the preceding year, $t-1$. X is a vector of parent-firm-level controls, including *Size*, *Tobin's Q*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. The regressions are estimated using the OLS estimator and include establishment, industry-year and state-year fixed effects, unless otherwise stated. Industry and state are defined at the establishment level. Variable definitions are provided in Appendix A. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The t-statistics in parentheses are based on heteroskedasticity-consistent and establishment-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	Ln(On-Site Pollution)				
Variable	(1)	(2)	(3)	(4)	(5)
CBE	-0.006***	-0.004***	-0.007***	-0.004*	-0.008**
	(-7.22)	(-5.15)	(-3.26)	(-1.90)	(-2.54)
Ln(Workforce)		0.652***	0.104***	0.094***	0.098***
		(27.23)	(4.46)	(4.18)	(4.36)
Size		-0.000	0.009	0.013	0.009
		(-0.03)	(0.51)	(0.74)	(0.55)
Tobin's Q		-0.559***	-0.050*	-0.028	-0.022
		(-10.22)	(-1.84)	(-1.04)	(-0.81)
Leverage		0.475**	0.417***	0.357***	0.373***
		(2.33)	(3.75)	(3.29)	(3.42)
Cash		0.631	-0.156	0.078	0.045
		(1.56)	(-0.78)	(0.39)	(0.23)
CAPEX		-1.382	-0.015	0.240	0.325
		(-1.63)	(-0.04)	(0.63)	(0.86)
Tangibility		6.649***	-0.422***	-0.183*	-0.206*
		(31.17)	(-3.79)	(-1.67)	(-1.90)
Profitability		4.105***	0.312	0.118	0.102
		(7.52)	(1.36)	(0.52)	(0.46)
Observations	165,500	165,500	163,148	163,036	162,985
Adj. R^2	0.003	0.111	0.837	0.842	0.843
Establishment FE	No	No	Yes	Yes	Yes
Year FE	No	No	Yes	No	No
Industry-Year FE	No	No	No	Yes	Yes
State-Year FE	No	No	No	No	Yes

Table 3. Effects of Protected Area Designations and Downgrading/Downsizing/Degazettement Events

This table presents the estimation results of the stacked DiD regression:

$$Ln(Pollution^i_{j,c,t}) = \alpha_0 + \beta_1 Treat^i_{j,c} \times Post_{c,t} + \beta_2 Ln(Workforce^i_{j,t}) + \Lambda' X^i_{t-1} + \gamma_{j,c} + \varphi_{ind,t,c} + \delta_{state,t,c} + \epsilon^i_{j,c,t}$$

where i, j, ind, $state$, c and t denote parent firm, establishment, industry, state, cohort and year, respectively. *Pollution* is alternatively the total on-site toxic chemical releases (*On-Site Pollution*) into the air, ground, and water by firm i's establishment j in year t, or the total toxic chemical transferred offsite for disposal (*Off-Site Pollution*). *Treat* equals one if firm i's establishment j in cohort c has its first protected area designation or downgraded/downsized/degazettement (DDD) within a 30-kilometer radius of its location and zero if the establishment is from the same state as the treated establishment but never experiences any designations or DDD events during our sample period. *Post* equals one for years subsequent to event year t within cohort c and zero otherwise. The unreported controls include facility-level *Workforce*, and parent-firm-level *Size*, *Tobin's Q*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. The regressions include establishment-cohort and industry-year-cohort fixed effects. Industry and state are defined at the establishment level. Variable definitions are provided in Appendix A. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The t-statistics in parentheses are based on heteroskedasticity-consistent and establishment-cohort-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	Ln(On-Site Pollution)		Ln(Off-site Pollution)	Ln(On-Site Pollution) (DDD)
Variable	(1)	(2)	(3)	(4)
Treat × Post	-0.553***		-0.027	0.024
	(-2.98)		(-0.15)	(0.22)
Treat × t =-4		0.372		
		(1.29)		
Treat × t =-3		0.283		
		(1.51)		
Treat × t = -2		-0.002		
		(-0.01)		
Treat × t =0		-0.490***		
		(-2.60)		
Treat × t =+1		-0.352**		
		(-2.39)		
Treat × t =+2		-0.334**		
		(-2.09)		
Treat × t =+3		-0.320*		
		(-1.77)		
Treat × t =+4		-0.583***		
		(-2.89)		
Observations	105,294	105,294	105,294	251,945
Adj R^2	0.834	0.834	0.770	0.914
Controls	Yes	Yes	Yes	Yes
Establishment-Cohort FE	Yes	Yes	Yes	Yes
Industry-Year-Cohort FE	Yes	Yes	Yes	Yes

Table 4. Effects of Biodiversity Exposure on Establishment Sales, Productivity, and Employment

This table investigates the effects of biodiversity conservation exposure on establishment-level sales, productivity, and employment. *Sales* is the natural log of the inflation-adjusted annual sales of an establishment in year t, expressed in 1990 U.S. dollars. *Productivity* is the natural log of one plus the ratio of an establishment's inflation-adjusted annual sales to the number of employees. *Workforce* is the number of an establishment's employees. *CBE* is the number of protected areas within a 30-km radius of an establishment's location. Parent-firm-level controls include *Size*, *Tobin's Q*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. The regressions in Columns (1)-(2) are estimated using the OLS estimator, whereas Column (3) is based on the PPML estimator. These regressions include establishment, industry-year, and state-year fixed effects. Industry and state are defined at the establishment level. Variable definitions are provided in Appendix A. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The t-statistics in parentheses are based on heteroskedasticity-consistent and establishment-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	Sales	Productivity	Workforce
Variable	(1)	(2)	(3)
CBE	-0.001**	-0.001**	-0.005*
	(-2.00)	(-2.06)	(-1.67)
Ln(Workforce)	0.977***	-0.003	
	(275.99)	(-1.00)	
Size	0.006***	0.006***	0.032***
	(2.72)	(2.92)	(5.35)
Tobin's Q	0.015***	0.015***	-0.015
	(3.37)	(3.80)	(-1.47)
Leverage	-0.065***	-0.051***	0.109***
	(-4.03)	(-3.30)	(2.58)
Cash	0.169***	0.180***	-0.108
	(6.56)	(7.54)	(-1.33)
CAPEX	-0.236***	-0.184***	-0.265*
	(-3.78)	(-3.49)	(-1.76)
Tangibility	0.052***	0.042**	-0.027
	(2.73)	(2.43)	(-0.57)
Profitability	0.226***	0.215***	-0.261***
	(5.39)	(5.82)	(-2.60)
Observations	162,985	162,985	162,985
Adj./Pseudo R^2	0.976	0.909	0.915
Establishment FE	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes

Table 5. Effects of Biodiversity Exposure on Establishment Abatement Investments

This table examines the effects of biodiversity conservation exposure on pollution abatement investment at the establishment level. In Column (1), the dependent variable is *Abatement*, defined as the number of source reduction activities adopted by an establishment in a given year. In Columns (2)-(4), these abatement activities are further categorized into three types: operational changes (*Operation-related abatement*), process improvements (*Process-related abatement*), and other modifications made to materials, product, or inventory management practices (*Other abatement*). *CBE* is the number of protected areas within a 30-km radius of an establishment's location. Parent-firm-level controls include *Size*, *Tobin's Q*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. The regressions are estimated using the PPML estimator and include establishment, industry-year, and state-year fixed effects. Industry and state are defined at the establishment level. Variable definitions are provided in Appendix A. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The t-statistics in parentheses are based on heteroskedasticity-consistent and establishment-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	Abatement	Operation-related abatement	Process-related abatement	Other abatement
Variable	(1)	(2)	(3)	(4)
CBE	-0.002	-0.007	-0.001	0.001
	(-0.64)	(-1.59)	(-0.31)	(0.25)
Ln(Workforce)	0.072***	0.065**	0.098***	0.078**
	(3.06)	(2.26)	(3.46)	(2.46)
Size	0.005	-0.022	0.020	0.014
	(0.24)	(-0.82)	(0.81)	(0.57)
Tobin's Q	0.013	0.043	0.011	-0.027
	(0.39)	(1.06)	(0.26)	(-0.61)
Leverage	0.120	0.044	-0.285	0.300
	(0.74)	(0.24)	(-1.59)	(1.58)
Cash	-0.266	-0.014	-0.686**	-0.095
	(-0.95)	(-0.04)	(-2.08)	(-0.29)
CAPEX	0.358	0.221	0.228	0.114
	(0.75)	(0.34)	(0.39)	(0.17)
Tangibility	-0.172	0.115	-0.121	-0.411*
	(-0.91)	(0.61)	(-0.57)	(-1.87)
Profitability	0.540	0.349	0.680	0.657
	(1.26)	(0.71)	(1.35)	(1.31)
Observations	87,524	51,327	61,297	61,386
Pseudo R^2	0.536	0.449	0.397	0.421
Establishment FE	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes

Table 6. Effects of Biodiversity Conservation on Firm-Level Financial Performance

This table presents the effects of biodiversity conservation exposure on parent-firm-level financial performance using the following regression model:

$$Performance_{i,t} \quad = \quad \alpha_0 + \beta_1 CBE^{\text{Parent}}_{i,t-1} + \Lambda' X_{i,t-1} + \gamma_i + \varphi_{ind,t} + \delta_{state,t} + \epsilon_{i,t},$$

where i, ind, $state$ and t denote parent firm, industry, state, and year, respectively. $Performance$ alternatively represents one of our four financial performance measures: (1) ROA, the ratio of earnings before interest, taxes, depreciation and amortization, scaled by lagged total assets; (2) *Productivity*, the natural logarithm of one plus the ratio of firm i's annual sales to the number of employees; (3) *TFP*, the total factor productivity computed using the residuals from estimating the log-transformed Cobb-Douglas production function: $Y_{i,t}=AL^{\beta}_{i,t}K^{\alpha}_{i,t}$, for each industry-year; (4) *Tobin's Q*, calculated as the book value of total assets minus the book value of common equity plus market capitalization, divided by total assets. CBE^{Parent} is the aggregated number of protected areas within a 30-km radius from the locations of all establishments owned by a parent firm i. The controls include *Size*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. These regressions are estimated using the OLS estimator and include parent-firm, industry-year, and state-year fixed effects. Industry and state are defined at the parent-firm level. Variable definitions are provided in Appendix A. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The t-statistics in parentheses are based on heteroskedasticity-consistent and establishment-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	ROA	Productivity	TFP	Tobin's Q
Variable	(1)	(2)	(3)	(4)
CBE^{Parent}	-0.002**	-0.010**	-1.249***	-0.014*
	(-2.26)	(-2.10)	(-2.77)	(-1.65)
Size	0.005***	0.034***	1.111	0.124***
	(4.12)	(4.97)	(1.62)	(9.33)
Leverage	-0.043***	-0.106***	-17.741***	-0.053
	(-5.41)	(-3.11)	(-5.57)	(-0.58)
Cash	-0.003	0.185***	25.302***	0.792***
	(-0.29)	(3.65)	(4.90)	(6.11)
CAPEX	0.039*	-0.086	12.068	0.498**
	(1.67)	(-0.84)	(1.19)	(2.48)
Tangibility	0.017**	0.026	-32.926***	0.044
	(2.12)	(0.59)	(-7.73)	(0.58)
Profitability	0.392***	0.749***	73.419***	1.111***
	(22.02)	(10.48)	(9.91)	(6.03)
Observations	23,933	23,933	23,933	23,933
Adj. R^2	0.579	0.903	0.78	0.635
Firm FE	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes

Table 7. The Regulatory Risks of Protecting Biodiversity

This table examines the effects of biodiversity conservation exposure on enforcement and inspection actions for environmental pollution at the establishment level. *Enforcement* is a binary indicator that equals one if an establishment is subject to at least one enforcement action for environmental violations, based on data from the ICIS FE&C database and zero otherwise. *Enforcement Count* is the number of enforcement actions (both non-judicial and judicial) that an establishment experiences in a given year. *Ln(Penalties)* is the natural log of the total amount of monetary penalties levied against an establishment by regulatory bodies for environmental enforcement actions. *Inspection* is a binary indicator that equals one if an establishment is inspected by regulatory agencies at least once in a given year. *Inspection Count* represents the number of pollution inspections that an establishment undergoes in a given year. Parent-firm-level controls include *Size*, *Tobin's Q*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. The regressions in Columns (1), (3), and (4) are estimated using the OLS estimator, while those in Columns (2) and (5) are based on the PPML estimator. All regressions include establishment, industry-year, and state-year fixed effects. Industry and state are defined at the establishment level. Variable definitions are provided in Appendix A. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The t-statistics in parentheses are based on heteroskedasticity-consistent and establishment-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	Enforcement	Enforcement Count	Ln(Penalties)	Inspection	Inspection Count
Variable	(1)	(2)	(3)	(4)	(5)
CBE	0.003*	0.011***	0.036**	-0.000	0.003*
	(1.87)	(2.78)	(2.00)	(-0.28)	(1.74)
Ln(Workforce)	0.008	0.024	0.107	-0.001	0.004
	(0.69)	(1.00)	(1.04)	(-0.32)	(0.54)
Size	-0.007	-0.009	0.032	0.004**	0.009
	(-0.65)	(-0.39)	(0.29)	(2.49)	(1.58)
Tobin's Q	0.024	0.043	0.402*	-0.001	-0.029**
	(1.15)	(0.90)	(1.79)	(-0.23)	(-2.58)
Leverage	-0.060	-0.270	-2.500***	0.024*	0.059
	(-0.77)	(-1.41)	(-3.11)	(1.94)	(1.30)
Cash	-0.198	0.249	-1.220	-0.012	-0.061
	(-1.29)	(0.70)	(-0.74)	(-0.53)	(-0.74)
CAPEX	0.172	-0.347	2.445	0.043	0.553***
	(0.57)	(-0.49)	(0.72)	(0.93)	(3.28)
Tangibility	-0.120*	-0.016	-1.477*	-0.021	-0.089**
	(-1.66)	(-0.10)	(-1.86)	(-1.62)	(-2.12)
Profitability	-0.069	-0.034	-0.358	-0.004	-0.040
	(-0.41)	(-0.09)	(-0.20)	(-0.13)	(-0.44)
Observations	6,754	5,343	6,754	162,985	110,713
Adj./Pseudo R^2	0.313	0.219	0.254	0.646	0.577
Establishment FE	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes

Table 8. Effects of Regulatory Risks and Biodiversity Conservation on On-Site Pollution

This table examines how regulatory risk channels the effects of biodiversity conservation exposure on On-Site Pollution. *Ln(On-Site Pollution)* is the natural log of total on-site toxic chemical releases (in pounds) into the air, ground, and water by an establishment in a given year. *Enforcement* is a binary indicator that equals one if an establishment is subject to at least one enforcement action for environmental violations, based on data from the ICIS FE&C database and zero otherwise.*Enforcement Count* is the number of enforcement actions (both non-judicial and judicial) that an establishment experiences in a given year. *Ln(Penalties)* is the natural log of the total amount of monetary penalties levied against an establishment for environmental enforcement actions. *Inspection* is a binary indicator that equals one if an establishment is inspected by regulatory bodies at least once during a given year. *Inspection Count* is the number of pollution inspections that an establishment undergoes in a given year. $CBE_{Gov\ Exposed}$ ($CBE_{Non\text{-}Gov\ Exposed}$) equals the number of protected areas within a 30-km radius of an establishment's location if at least one (none of) protected area is governed by either federal or local government agencies and zero otherwise. *Government Exposure* represents a text-based measure of the parent firm's exposure to federal environmental regulatory bodies based on Armstrong, Glaeser, and Hoopes (2024). The unreported controls include facility-level *Workforce*, and parent-firm-level *Size*, *Tobin's Q*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. The regressions are estimated using the OLS estimator and include establishment, industry-year, and state-year fixed effects unless otherwise stated. Variable definitions are provided in Appendix A. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The t-statistics in parentheses are based on heteroskedasticity-consistent and establishment-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	Ln(On-Site Pollution)						
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CBE × Enforcement	-0.004*						
	(-1.75)						
Enforcement	0.072						
	(1.10)						
CBE × Enforcement Count		-0.002*					
		(-1.94)					
Enforcement Count		0.028					
		(1.13)					
CBE × Ln(Penalties)			-0.000**				
			(-2.46)				
Ln(Penalties)			0.009				
			(1.60)				
CBE × Inspection				0.000			
				(0.85)			
Inspection				0.121***			
				(4.46)			
CBE × Inspection Count					0.000		
					(0.70)		
Inspection Count					0.033***		
					(8.57)		
$CBE_{Gov\ Exposed}$						-0.008**	
						(-2.52)	
$CBE_{Non\text{-}Gov\ Exposed}$						0.018	
						(0.60)	
CBE × Government Exposure							-0.000**
							(-2.01)
Government Exposure							-0.001
							(-0.34)
CBE	0.005	0.004	0.006	-0.009***	-0.009***		-0.007*
	(0.42)	(0.41)	(0.53)	(-2.64)	(-2.61)		(-1.84)
Observations	6,754	6,754	6,754	162,985	162,985	162,985	96,923
Adj. R^2	0.877	0.877	0.877	0.843	0.843	0.843	0.884
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Establishment FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 9. Cross-Sectional Analyses

This table examines the heterogeneous effects of biodiversity conservation exposure on On-Site Pollution across different establishment-, firm-, and industry-level attributes. *On-Site Pollution* is the natural log of total on-site toxic chemical releases (in pounds) into the air, ground, and water by an establishment in a given year. *Polluter* is a binary indicator that takes the value of one if the establishment-level On-Site Pollution is above the sample median and zero otherwise. *Financial Constraints* is a binary indicator that equals one if the parent firm is financially constrained, classified based on Kaplan and Zingales's (1997) index. *Impact* is an indicator variable that is set to one for establishments operating in industries with above-median pressure materiality scores. *Dependence* is an indicator variable that is set to one for establishments operating in industries that are dependent on the natural capital with above-median dependency materiality scores. The unreported controls include facility-level *Workforce*, and parent-firm-level *Size*, *Tobin's Q*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. All regressions are estimated using the OLS estimator and include establishment, industry-year, and state-year fixed effects. Industry and state are defined at the establishment level. Variable definitions are provided in Appendix A. The continuous variables are winsorized at the top and bottom 1% of the sample distribution. The *t*-statistics in parentheses are based on heteroskedasticity-consistent and establishment-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	Ln(On-Site Pollution)			
Variable	(1)	(2)	(3)	(4)
CBE × Polluter	-0.002*			
	(-1.86)			
Polluter	3.420***			
	(65.01)			
CBE × Financial Constraints		0.001*		
		(1.81)		
Financial Constraints		-0.114***		
		(-3.66)		
CBE × Impact			-0.001	
			(-0.58)	
Impact			0.076	
			(0.60)	
CBE × Dependence				-0.003
				(-1.44)
Dependence				0.034
				(0.32)
CBE	-0.006**	-0.009**	-0.007**	-0.007**
	(-2.38)	(-2.47)	(-2.18)	(-2.17)
Observations	154,472	149,431	159,192	162,985
Adj. R^2	0.880	0.846	0.847	0.843
Controls	Yes	Yes	Yes	Yes
Establishment FE	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	No	No
State-Year FE	Yes	Yes	Yes	Yes

Table 10. Robustness Tests

This table presents the regression results of establishment-level on-site toxic releases on alternative regression estimation and measures of corporate biodiversity exposure. $CBE_{IUCNCat}$ is calculated by summing the total number of protected areas within a 30-kilometer radius of each establishment, with each area assigned a weight based on its IUCN category. Protected areas classified as IUCN Categories Ia and Ib were assigned a weight of 6, Category II received a weight of 5, Category III a weight of 4, Category IV a weight of 3, Category V a weight of 2, and Category VI plus other or unreported categories a weight of 1. CBE_{Area} represents the natural log of the total surface area of protected areas within a 30 km radius around an establishment in a given year, while $CBE_{IntersectionArea}$ considers only the portion of the surface area that intersects a 30 km buffer zone around the establishment. $CBE_{Employment}$ is the number of protected areas within a 30 km radius of an establishment's location, weighted by the ratio of its employment relative to the aggregate employment across all establishments in our sample in a given year. CBE_{Sales} is defined similarly but uses inflation-adjusted annual sales figures to determine the weighting factor. The unreported controls include facility-level *Workforce*, and parent-firm-level *Size*, *Tobin's Q*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. The regression in Column (1) is estimated using the PPML estimator, while those from Columns (2)-(6) are based on the OLS estimator. All regressions include establishment, industry-year, and state-year fixed effects. Industry and state are defined at the establishment level. Variable definitions are provided in Appendix A. The continuous variables are winsorized at the top and bottom 1% of the sample distribution. The t-statistics in parentheses are based on heteroskedasticity-consistent and establishment-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	Ln(On-Site Pollution)					
	PPML	OLS				
Variable	(1)	(2)	(3)	(4)	(5)	(6)
CBE	-0.006**					
	(-1.98)					
$\text{CBE}_{IUCNCat}$		-0.004**				
		(-2.48)				
CBE_{Area}			-0.052*			
			(-1.78)			
$\text{CBE}_{IntersectionArea}$				-0.074**		
				(-2.29)		
$\text{CBE}_{Employment}$					-0.025*	
					(-1.67)	
CBE_{Sales}						-0.047*
						(-1.75)
Observations	146,839	162,985	162,985	162,985	162,985	162,985
Adj. R^2	0.933	0.843	0.843	0.843	0.843	0.843
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Establishment FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Appendix A. Variable Definition and Data Source

Variable	Definition and Data Source
Measures of Toxic Releases	
On-Site Pollution	The amount of toxic chemicals (measured in pounds) released on-site by an establishment into air, water, and ground in a given year. (US EPA TRI Database)
Off-Site Pollution	The amount of toxic chemicals (measured in pounds) transferred off-site for disposal by an establishment in a given year. (US EPA TRI Database)
Corporate Biodiversity Exposure Measures	
CBE	The location-based corporate biodiversity exposure metric, defined as the number of protected areas (PAs) within a 30-km radius from an establishment's location in the preceding year. (WDPA & NETS TRI Databases)
CBE^{Parent}	The aggregated number of protected areas within a 30-km radius from the locations of all establishments owned by a parent firm. (WDPA & NETS TRI Databases)
$\text{CBE}_{\textit{Gov Exposed}}$	The number of PAs within a 30-km radius from an establishment's location in the preceding year if at least one is governed by either federal or local government agencies and zero otherwise. (WDPA & NETS TRI Databases)
$\text{CBE}_{\textit{Non-Gov Exposed}}$	The number of PAs within a 30-km radius from an establishment's location in the preceding year if none of these PAs is governed by either federal or local government agencies and zero otherwise. (WDPA & NETS TRI Databases)
$\text{CBE}_{IUCNCat}$	The number of PAs within a 30-km radius from an establishment's location in the preceding year, with each area assigned a weight based on its IUCN category. (WDPA & NETS TRI Databases)
CBE_{Area}	The natural log of total surface area of protected areas within a 30-km radius from an establishment's location in the preceding year. (WDPA & NETS TRI Databases)
$\text{CBE}_{IntersectionArea}$	The natural log of total surface area of protected areas that intersect with the 30-km buffer zone from an establishment's location in the preceding year. (WDPA & NETS TRI Databases)
$\text{CBE}_{Employment}$	The number of PAs within a 30-km radius from an establishment's location, weighted by the ratio of its employment to the aggregate employment across all establishments in our sample in a given year. (WDPA & NETS TRI Databases)
CBE_{Sales}	The number of PAs within a 30-km radius from an establishment's location, weighted by the ratio of its annual sales to the aggregate annual sales across all establishments in our sample in a given year. (WDPA & NETS TRI Databases)
Establishment-Level Variables	
Sales	The natural log of one plus an establishment's inflation-adjusted annual sales (expressed in 1990 $million) in a given year. (NETS TRI Database)

Productivity	The natural log of one plus the ratio of an establishment's inflation-adjusted annual sales scaled by its total number of employees in a given year. (NETS TRI Database)
Workforce	The number of an establishment's employees in a given year. (NETS TRI Database)
Abatement	The number of source reduction activities (for all toxic chemicals) adopted by an establishment in a given year. (US EPA TRI Pollution Prevention P2 Database)
Operation-related abatement	The number of source reduction activities in form of operational changes adopted by an establishment in a given year. (US EPA TRI Pollution Prevention P2 Database)
Process-related abatement	The number of source reduction activities in form of production process improvements adopted by an establishment in a given year. (US EPA TRI Pollution Prevention P2 Database)
Other abatement	The number of source reduction activities in form of other modifications made to materials, product, or inventory management practices adopted by an establishment in a given year. (US EPA TRI Pollution Prevention P2 Database)
Enforcement	A binary indicator for establishments subject to at least one enforcement action for their environmental violations in a given year and zero otherwise. (ICIS FE&C Database)
Enforcement Count	The number of enforcement actions undertaken against an establishment for their environmental violations in a given year. (ICIS FE&C Database)
Penalties	The total amount of monetary penalties levied against an establishment for environmental regulatory violations. (ICIS FE&C Database)
Inspection	A binary indicator for establishments inspected by environmental regulatory bodies at least once in a given year and zero otherwise. (ICIS FE&C Database)
Inspection Count	The number of inspections undertaken at an establishment by environmental regulatory bodies in a given year. (ICIS FE&C Database)
Polluter	A binary indicator that equals one if an establishment's prior-year *On-Site Pollution* lies above the sample median and zero otherwise. (US EPA TRI Database)

Parent-Firm-Level Variables

ROA	Earnings before interest, taxes, depreciation and amortization, scaled by lagged total assets. (Compustat)
Productivity	The natural logarithm of one plus the ratio of a parent firm's annual sales scaled by its number of employees in a given year. (Compustat)
TFP	The residuals from an estimated log-transformed Cobb-Douglas production function $Y_{i,t}=AL_{i,t}^{\beta}K_{i,t}^{\alpha}$ for each industry-year, where L is the parent firm's number of employees and K stands for the net book value of property, plant, and equipment. (Compustat)
Tobin's Q	The book value of total assets minus the book value of common equity plus market capitalization, divided by the book value of total assets. (Compustat)
Size	The natural log of the parent firm's market capitalization. (CRSP, Compustat)

Leverage	The sum of long-term and short-term debt, scaled by total assets. (Compustat)
Cash	The ratio of cash and short-term investments to total assets. (Compustat)
CAPEX	The parent firm's capital expenditure scaled by the prior-year total assets. (Compustat)
Tangibility	The value of net property, plant, and equipment scaled by the prior-year total assets. (Compustat)
Profitability	The ratio of earnings before interest and taxes divided by total sales. (Compustat)
Financial Constraints	A binary indicator for financially constrained parent firms based on Kaplan and Zingales's (1997) index, constructed following the approach used in Lamont, Polk, and Saá-Requejo (2001). This variable equals one if a parent firm's KZ index in a given year is above the sample median and zero otherwise. (Compustat)
Other Variables	
Impact	A binary indicator for establishments operating in industries that exert significant pressure on the ecosystem with average pressure scores lie above the sample median and zero otherwise. (ENCORE Database)
Dependence	A binary indicator for establishments operating in industries that significantly depend upon the ecosystem services with average dependency scores lie above the sample median and zero otherwise. (ENCORE Database)

Online Appendix

to Accompany

The Real Effects of Protecting Biodiversity

Figure OA1. Univariate Analysis of CBE Effects by Distance

The plot displays the coefficient estimates of CBE measures across various concentric rings, along with their corresponding 90% confidence intervals. The numbers at the coefficient estimates represent the calculated economic magnitude of the CBE effects in pounds. For example, a firm's exposure to one additional newly designated is associated with about 3% decrease in on-site toxic emissions, equivalent to a reduction of 4,037 pounds in emissions (calculated as $(e^{-0.0315} - 1) \times 130{,}205$, where 130,205 is the mean of *On-Site Pollution*)).

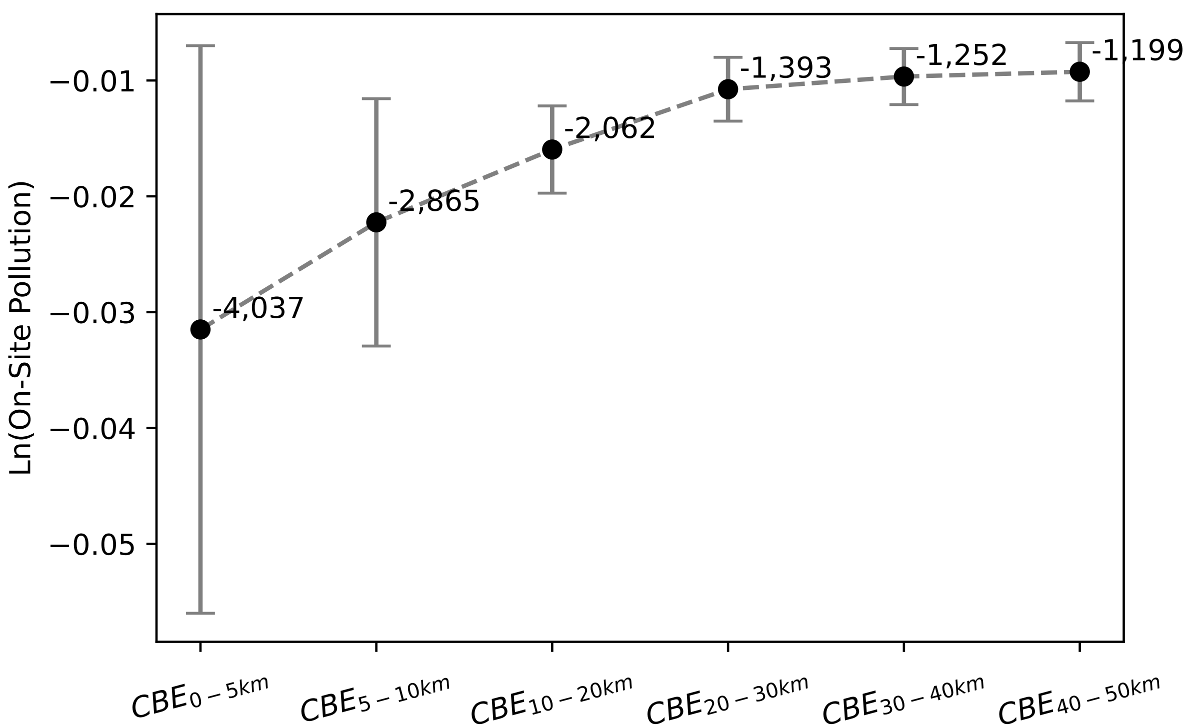

Table OA1. IUCN's Protected Area Management Categories

Category	Category Name	Definition
Category Ia	Strict nature reserve	Strictly protected areas set aside to protect biodiversity and also possibly geological or landform features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.
Category Ib	Wilderness area	These protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.
Category II	National park	These protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.
Category III	Natural monument or feature	These protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.
Category IV	Habitat/Species management area	These protected areas aim to protect particular species or habitats and management reflects this priority. Many category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.
Category V	Protected landscape/seascape	The protected area where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.
Category VI	Protected area with sustainable use of natural resources	These protected areas conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.

Table OA2. Supplementary Summary Statistics

This table presents supplementary summary statistics for corporate biodiversity exposure metric (*CBE*) across different radii (Panel A), alongside other establishment- and firm-level outcome variables used in the regression models presented in Tables 4-6 (Panels B and C). All variables are measured annually. *CBE* is the biodiversity conservation exposure, defined as the number of protected areas located within a specified radius from an establishment's location in the preceding year, $t-1$. *Adjusted sales* (in \$ million) is the inflation-adjusted annual sales of an establishment, expressed in 1990 dollars. *Sales* is the natural log of an establishment's inflation-adjusted annual sales. *Sales per employee* (in \$) is the ratio of an establishment's inflation-adjusted sales to its number of employees. *Productivity* is the natural log of *Sales per employee*. *Abatement* is the total number of pollution abatement activities that an establishment adopts to reduce toxic chemical emissions in a given year. *Operation-related abatement* represents the number of those abatement activities in the form of operational adjustments. *Process-related abatement* is the number of abatement investments in the form of changes in production process. *Other abatement* is the number of abatement activities in form of other modifications made to materials, product, or inventory management practices adopted by an establishment. *ROA* is the ratio of earnings before interest, taxes, depreciation and amortization to lagged total assets. *TFP* is computed using the residuals from estimating the log-transformed Cobb-Douglas production function: $Y_{i,t}=AL_{i,t}^{\beta}K_{i,t}^{\alpha}$, for each industry-year. *Tobin's Q* is defined as the book value of total assets minus the book value of common equity plus market capitalization, divided by total assets. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The sample period spans from 1990 to 2021.

Panel A: Corporate Biodiversity Exposure Measures

Variable	Observations	Mean	SD	25%	50%	75%
CBE_{0-5km}	165,500	0.579	3.643	0.000	0.000	0.000
CBE_{0-10km}	165,500	2.028	11.34	0.000	0.000	2.000
CBE_{0-20km}	165,500	6.606	25.39	0.000	2.000	5.000
CBE_{0-40km}	165,500	22.13	71.07	3.000	8.000	16.00
CBE_{0-50km}	165,500	31.89	97.09	5.000	12.00	23.00
CBE_{5-10km}	165,500	1.449	8.013	0.000	0.000	1.000
$\text{CBE}_{10-20km}$	165,500	4.578	16.94	0.000	1.000	3.000
$\text{CBE}_{20-30km}$	165,500	6.909	24.55	1.000	2.000	5.000
$\text{CBE}_{30-40km}$	165,500	8.618	28.66	1.000	3.000	6.000
$\text{CBE}_{40-50km}$	165,500	9.752	29.84	1.000	4.000	7.000

Panel B: Other Establishment-Level Variables

Variable	Observations	Mean	SD	25%	50%	75%
Adjusted sales ($ million)	165,500	62.40	125.0	8.236	22.90	57.90
Sales	165,500	16.83	1.620	15.92	16.95	17.87
Sales per employee ($)	165,500	225.6	296.7	95.55	140.5	226.7
Productivity	165,500	5.059	0.744	4.570	4.952	5.428
Abatement	165,500	0.765	3.259	0.000	0.000	0.000
Operation-related abatement	165,500	0.219	1.203	0.000	0.000	0.000
Process-related abatement	165,500	0.205	1.011	0.000	0.000	0.000
Other abatement	165,500	0.219	1.123	0.000	0.000	0.000

Panel C: Other Parent-Firm-Level Variables

Variable	Observations	Mean	SD	25%	50%	75%
CBE	24,505	0.704	1.498	0.060	0.190	0.590
ROA	24,505	0.142	0.092	0.089	0.136	0.191
Productivity	24,505	5.540	0.779	5.007	5.452	5.951
TFP	24,505	0.894	51.66	-30.78	-4.056	26.54
Tobin's Q	24,505	1.642	0.859	1.102	1.379	1.873

Table OA3. The Regulatory Risk of Protecting Biodiversity - Alternative Model

This table replicates the empirical tests presented in Table 8 by extending the estimated models with an additional control for the establishment's prior-year pollution. *Enforcement* is a binary indicator that equals one if an establishment is subject to at least one environmental enforcement action, based on data from the ICIS FE&C database and zero otherwise. *Enforcement Count* is the number of enforcement actions (both non-judicial and judicial) that an establishment experiences in a given year. *Ln(Penalties)* is the natural log of the total amount of monetary penalties levied against an establishment by regulatory agencies for environmental violations. *Inspection* is a binary indicator that equals one if an establishment is inspected by regulatory agencies at least once during a given year. *Inspection Count* represents the number of pollution inspections that an establishment undergoes in a given year. *CBE* is the number of protected areas within a 30-km radius of an establishment's location. *Ln(Total Releases)* is the natural log of an establishment's amount of toxic chemical releases in the prior year. *Ln(Workforce)* is the natural log of the number of an establishment's employees. Parent-firm-level controls include *Size*, *Tobin's Q*, *Leverage*, *Cash*, *CAPEX*, *Tangibility*, and *Profitability*. The regressions in Columns (1), (3), and (4) are estimated using the OLS estimator, while those in Columns (2) and (5) are based on the PPML estimator. All regressions include establishment, industry-year, and state-year fixed effects. Industry and state are defined at the establishment level. All continuous variables are winsorized at the top and bottom 1% of the sample distribution. The t-statistics in parentheses are based on heteroskedasticity-consistent and establishment-level clustered standard errors. The symbols ***, **, and * denote the statistical significance at 1%, 5%, and 10% levels, respectively. The sample period is from 1990 to 2021.

	Enforcement	Enforcement Count	Ln(Penalties)	Inspection	Inspection Count
Variable	(1)	(2)	(3)	(4)	(5)
CBE	0.003*	0.021**	0.032*	0.000	0.003*
	(1.67)	(2.10)	(1.73)	(0.25)	(1.90)
Ln(Total Releases)	0.006	-0.000	0.079	0.003***	0.017***
	(1.16)	(-0.00)	(1.56)	(5.18)	(6.71)
Ln(Workforce)	0.006	0.024	0.124	-0.000	-0.002
	(0.49)	(0.71)	(1.17)	(-0.06)	(-0.29)
Size	-0.008	0.011	0.017	0.003*	0.010*
	(-0.74)	(0.32)	(0.16)	(1.84)	(1.69)
Tobin's Q	0.024	0.114*	0.412*	0.001	-0.025**
	(1.13)	(1.78)	(1.79)	(0.19)	(-2.03)
Leverage	-0.082	-0.162	-2.753***	0.024**	0.066
	(-1.02)	(-0.68)	(-3.36)	(1.97)	(1.42)
Cash	-0.191	0.301	-1.161	-0.012	-0.067
	(-1.22)	(0.59)	(-0.70)	(-0.54)	(-0.80)
CAPEX	0.271	-0.336	3.480	0.038	0.326*
	(0.87)	(-0.39)	(0.99)	(0.80)	(1.83)
Tangibility	-0.104	0.156	-1.337	-0.022	-0.071
	(-1.41)	(0.78)	(-1.64)	(-1.60)	(-1.64)
Profitability	-0.127	-0.562	-0.877	0.001	-0.043
	(-0.73)	(-1.14)	(-0.48)	(0.03)	(-0.44)
Observations	6,558	3,997	6,558	154,472	105,670
Adj./Pseudo R^2	0.309	0.257	0.253	0.647	0.584
Establishment FE	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes	Yes	Yes

Table OA4. List of the Most Impactful and Dependent Industries on Natural Capital

This table reports the average ENCORE pressure and dependency materiality ratings across 25 ecosystem services for the 10 most impactful and dependent industries on natural capital in our sample. The industries are classified based on the six-digit NAICS codes.

Panel A: Ten Most Impactful Industries on Natural Capital

NAICS code	Industry name	Average pressure score
113210	Forest Nurseries and Gathering of Forest Products	5.222
221112	Fossil Fuel Electric Power Generation	5.125
112120	Dairy Cattle and Milk Production	5.100
111140	Wheat Farming	5.000
212221	Gold Ore Mining	4.909
212222	Silver Ore Mining	4.909
212230	Copper, Nickel, Lead, and Zinc Mining	4.909
212299	All Other Metal Ore Mining	4.909
115114	Postharvest Crop Activities (except Cotton Ginning)	4.857
324199	All Other Petroleum and Coal Products Manufacturing	4.857

Panel B: Ten Most Dependent Industries on Natural Capital

NAICS code	Industry name	Average dependency score
111421	Nursery and Tree Production	5.429
113210	Forest Nurseries and Gathering of Forest Products	5.263
111219	Other Vegetable (except Potato) and Melon Farming	5.211
111140	Wheat farming	5.053
311710	Seafood Product Preparation and Packaging	5.000
112120	Dairy Cattle and Milk Production	4.381
113310	Logging	4.263
115114	Postharvest Crop Activities (except Cotton Ginning)	4.158
112210	Hog and Pig Farming	4.150
212311	Dimension Stone Mining and Quarrying	4.067