Extended Abstract

Consequences of Land Use Regulation Under the Clean Water Act*

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Abstract

How does environmental regulation of land use affect the environment and the economy? We analyze how dramatic recent changes in Clean Water Act regulation due to White House and Supreme Court rules, measured using geophysical data and machine learning algorithms, affect property values and land use. Four findings emerge. First, recent rule changes greatly alter regulatory stringency. Second, regulation substantially decreases values of non-residential land parcels with water resources. Third, regulation decreases development activity, as measured from permitting and satellite data. Fourth, we calculate implied costs of this regulation.

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Many prominent environmental policies restrict land development. The US Endangered Species Act, for example, constrains land use in habitats of critically-threatened species. The National Environmental Policy Act requires developers to undertake a costly planning process intended to minimize environmental damage due to development.

Such environmental regulations of land use attract substantial controversy over whether they optimally balance environmental benefits and economic costs. Land use restrictions constrain the supply of developed land, and Hsieh and Moretti (2019) estimate that labor misallocation due to land use regulation has substantially decreased US growth. Undeveloped plots are increasingly located in areas subject to climate change-related hazards like wildfires (Radeloff et al. 2018), and restricting land available for development could exacerbate those hazards. At the same time, restricting development can preserve ecosystem services that undeveloped lands provide such as flood mitigation, wildfire mitigation, biodiversity, pest control, and air quality.

The 1972 Clean Water Act provides an important setting to study these tradeoffs. Although the Clean Water Act directly regulates pollution in US waterways, its implementation ultimately affects land use and real estate development. Section 404 of the Act restricts the discharge of "dredge and fill material" into jurisdictional waters, and a regulation which the US Army Corps of Engineers helps implement. In the early 1970s, the Army Corps interpreted Section 404 to cover traditional navigable waterways, i.e., rivers that a boat could navigate, which Congress regulates under the Constitution's Interstate Commerce Clause.

In the late 1970s, however, the Environmental Protection Agency interpreted that the Clean Water Act protected water resources upstream of traditional navigable waters. This interpretation eventually expanded Clean Water Act jurisdiction to wetlands where water is present infrequently or even only historically; desert washes and ephemeral streams, where water is present only a few days per year; and other areas where land development could otherwise easily occur. The Section 404 restrictions on dredging and filling limit most construction activity involving heavy machinery like bulldozers and excavators which occurs on jurisdictional areas, and thus translate a statute focused on managing pollution in US surface waters to a statute affecting development across many US lands.

Since its inception, acrimonious debates have occurred about the appropriate jurisdiction of the Clean Water Act, and especially Section 404. One third of US Supreme Court environmental rulings since 1972 address the Clean Water Act, more by far than for any other environmental law (Zellmer 2013). In just the last decade, regulatory ping-pong due to judicial and executive branch rulings has dramatically and repeatedly changed Clean Water Act jurisdiction. These reforms provide both reason to study the Act's impacts and a research design to estimate those impacts. Until 2015, Justice Kennedy's concurring opinion in the Supreme Court's *Rapanos* decision guided jurisdiction, and directed that the Clean Water Act protected waters which were a "significant nexus" to navigable waters, including a biological, physical, or chemical connection—a decision which ultimately regulated many wetlands and ephemeral streams. In 2015, the Obama Administration issued the Clean Water Rule, clarifying which waters were protected and not seeking to substantially change jurisdiction. Twenty-seven states litigated and never implemented this rule.

Our analysis focuses on arguably the largest recent change in Clean Water Act jurisdiction—the Trump Administration's Navigable Waters Protection Rule (NWPR), which essentially required a continuous and relatively permanent surface water connection between a regulated waterbody and a traditionally-navigable waterway. NWPR substantially limited jurisdiction for isolated wetlands (i.e., wetlands without a surface water connection) and ephemeral streams.

Clean Water Act jurisdiction is controversial due to its potential economic and environmental consequences. To determine whether the Clean Water Act regulates parts of a potential development site, landowners or developers typically hire a wetland consultant to conduct a field survey indicating whether any water features may be regulated. If so, developers must obtain a permit and undertake costly actions such as minimizing impacts to regulated waters, purchasing environmental offsets from wetland banks, and in many cases leaving the area of the jurisdictional water resource undeveloped. These regulations can affect any type of land development project including factories, renewable or fossil fuel power plants, roads, airports, golf courses, oil and gas drilling, mining, housing, warehouses, and others. At the same time, isolated wetlands, ephemeral streams, and other water resources that are not traditionally navigable account for a large share of water flow and potential ecosystem services such as pollution filtration and flood mitigation (Brinkerhoff et al. 2024).

Our analysis of this regulation proceeds in four steps. First, using data on legally-binding Approved Jurisdictional Determinations (AJDs) from the Environmental Protection Agency and Army Corps, we examine how NWPR affected regulatory stringency. We find that developer requests for determinations increased fourfold during NWPR. The share of Army Corps-evaluated sites deemed jurisdictional under NWPR decreased by 6 percentage points for sites without water resources, but the share decreased by up to 20 percentage points for sites with water resources.

Second, we examine how variation in jurisdiction affects development. We report event study analyses of changes in remotely-sensed measures of development in years surrounding project-level Army Corps jurisdictional determinations. Development becomes substantially more likely following a jurisdictional determination, particularly when the site is not regulated.

Third, using parcel-level data from CoreLogic on the near-universe of US land transactions, we study how the introduction of NWPR affected land markets. We focus on non-residential parcels, where development is more likely to occur after a sale. We find that NWPR substantially increased the value of water resource parcels, though only on non-residential properties. Relative to non-residential parcels with no water resources present, we estimate that NWPR significantly increased land values of non-residential parcels with water resources.

We then incorporate a machine learning model of regulation to obtain estimates of how the predicted probability of jurisdiction affects property values. Although Army Corps data reveal how NWPR changes the regulatory stringency of the Clean Water Act, and land market data reveal how NWPR changes property values, we cannot use standard instrumental variables models to estimate the effects of regulation because there is limited spatial overlap between the Army Corps and land market data. Instead, we use a model based on prior work (Greenhill et al. 2024) to predict a given location's probability of being regulated under different Clean Water Act rules. We then estimate how the probability of jurisdiction under the rule in force at the time of the property sale affects land values.

Several aspects of the analysis help assess internal validity. First, event study analyses allow assessment of how property values changed when NWPR began in early 2020, versus when a judicial ruling stayed NWPR in late 2021. Second, because the period when NWPR was in force largely overlaps with the COVID-19 pandemic, we investigate the sensitivity of our results to adding parcel-level controls for three proxies for the COVID housing boom (Ramani et al. 2024): the share of individuals who can work from home, the distance to the closest central business district, and population density. Third, we compare NWPR's land market effects for non-residential parcels, where development is likely following a transaction, versus residential parcels, where single-family homes or other buildings constrain new development. Fourth, semi-parametric bin estimates show that non-residential parcels with relatively larger shares of area deregulated experienced relatively larger changes in property values, while residential parcels show no such pattern. Fifth, we find similar effects of NWPR on non-residential land values in both regions with large and small COVID housing booms.

The fourth and final part of our research estimates the economic cost of Clean Water Act regulation by combining the results of our regulatory stringency and land market impact analyses.

This research departs from existing work in several ways. We believe it provides the first ex post estimate of the costs or impacts of Clean Water Act regulation on land use. The leading estimate of the cost of Clean Water Act land use regulations comes from a survey measuring fees and time completing paperwork (Sunding and Zilberman 2002). An EPA Economic Analysis of the Biden Administration's Clean Water Act rule assumes these regulations require permit fees and mitigation costs but do not change property values (EPA and USACE 2021). Prominent media stories describe these reforms (Davenport 2020; Ferek and Puko 2020; Daly 2021) and describe how these changes in Clean Water Act rules have allowed large construction projects (Cassels 2021; Magill 2021). Five *Science* papers debate NWPR's scientific justifications, but do not study its ex post economic or environmental effects (Boyle et al. 2017; Sullivan et al. 2020; Keiser et al. 2021; Brinkerhoff et al. 2024; Greenhill et al. 2024). In contrast, there exists much economic research estimating ex post costs of other major environmental regulations, including the Clean Air Act (Becker and Henderson 2000; Greenstone 2002; Walker 2013; Shapiro and Walker 2024) and the Endangered Species Act (Auffhammer et al. 2020; Frank et al. 2025).

We also believe this research provides the first comprehensive analysis of the Clean Water Act's Section 404 regulation of land use. A few studies analyze the Clean Water Act's grants for abatement technology at wastewater treatment plants (Keiser and Shapiro 2019; Flynn and Marcus 2021; Jerch 2021). Other work studies the Clean Water Act's abatement technology requirements for industrial plants (Behrer et al. 2021; Earnhart and Segerson 2012). These are separate from the regulations we study.

More broadly, this research provides novel estimates of the cost of protecting wetlands, which are a critical natural resource globally. Wetlands create a classic positive externality since they mitigate floods, improve water quality, and provide other benefits to other properties (Heimlich 1998; Turner et al. 2000). A few economic papers analyze particular aspects of wetlands: Taylor and Druckenmiller (2022) use spatial and temporal variation in US wetlands to estimate their flood protection benefits; Aronoff and Rafey (2023) study offset markets for wetlands in Florida; Stavins and Jaffe (1990) model how flood prevention and land use projects in the Mississippi Valley change supply of forested wetlands. Our sense is that economic research on wetlands is inefficiently scarce relative to wetlands' global environmental and economic importance, which is arguably growing given wetlands' potential role in climate adaptation via flood mitigation.

References

Aronoff, Daniel, and Will Rafey. 2023. *Conservation priorities and environmental offsets: Markets for Florida wetlands.* Technical report. National Bureau of Economic Research.

Auffhammer, Maximilan, Maya Duru, Edward Rubin, and David L. Sunding. 2020. "The Economic Impact of Critical-Habitat Designation: Evidence from Vacant-Land Transactions." *Land Economics* 96 (2): 188–206.

Becker, Randy, and Vernon Henderson. 2000. "Effects of Air Quality Regulations on Polluting Industries." *Journal of Political Economy* 108(2):379–421.

Behrer, A. Patrick, Edward L. Glaeser, Giacomo A. M. Ponzetto, and Andrei Shleifer. 2021. "Securing Property Rights." *Journal of Political Economy* 129 (4): 1157–1192.

Boyle, Kevin J, Matthew J Kotchen, and V Kerry Smith. 2017. "Deciphering dueling analyses of clean water regulations." *Science* 358 (6359): 49–50.

Brinkerhoff, Craig B, Colin J Gleason, Matthew J Kotchen, Douglas A Kysar, and Peter A Raymond. 2024. "Ephemeral stream water contributions to United States drainage networks." *Science* 384 (6703): 1476–1482.

Cassels, Laura. 2021. *FL wetlands and waterways face development and potential harm as vacated Trump rules linger.* https://floridaphoenix.com/2021/10/18/fl-wetlands-and-waterways-face-development-and-potential-harm-as-vacated-trump-rules-linger/.

Daly, Mathew. 2021. *Biden moves to restore clean-water safeguards ended by Trump.*

Davenport, Coral. 2020. *Trump Removes Pollution Controls on Streams and Wetlands.*

Earnhart, Dietrich, and Kathleen Segerson. 2012. "The influence of financial status on the effectiveness of environmental enforcement." *Journal of Public Economics* 96 (9-10): 670–684.

EPA and USACE. 2021. *Economic Analysis for the Proposed Revised Definition Of "Waters of the United States" Rule.* https://www.epa.gov/system/files/documents/2021-11/revised-definition-of-wotus_nprm_economic-analysis.pdf.

Ferek, Katy Stech, and Timothy Puko. 2020. *EPA Releases New Clean-Water Rules Scaling Back Federal Oversight.*

Flynn, Patrick, and Michelle Marcus. 2021. *A Watershed Moment: The Clean Water Act and Infant Health.*

Frank, Eyal G., Maximilian Auffhammer, David McLaughlin, Elisheba Spiller, and David L. Sunding. 2025. "The Cost of Species Protection: The Land Market Impacts of the Endangered Species Act." NBER Working Paper 33352.

Greenhill, Simon, Hannah Druckenmiller, Sherrie Wang, David A Keiser, Manuela Girotto, Jason K Moore, Nobuhiro Yamaguchi, Alberto Todeschini, and Joseph S Shapiro. 2024. "Machine learning predicts which rivers, streams, and wetlands the Clean Water Act regulates." *Science* 383 (6681): 406–412.

Greenstone, Michael. 2002. "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures." *Journal of Political Economy* 110(6):1175–1219.

Heimlich, Ralph E. 1998. *Wetlands and agriculture: Private interests and public benefits.* 765. US Department of Agriculture, Economic Research Service.

Hsieh, Chang-Tai, and Enrico Moretti. 2019. "Housing constraints and spatial misallocation." *American Economic Journal: Macroeconomics* 11 (2): 1–39.

Jerch, Rhiannon L. 2021. *The Local Benefits of Federal Mandates: Evidence from the Clean Water Act.*

Keiser, David A, and Joseph S Shapiro. 2019. "Consequences of the Clean Water Act and the demand for water quality." *The Quarterly Journal of Economics* 134 (1): 349–396.

Keiser, David A., Sheila M. Olmstead, Kevin J. Boyle, Victor B. Flatt, Bonnie L. Keeler, Catherine L. Kling, Daniel J. Phaneuf, Joseph S. Shapiro, and Jay P. Shimshack. 2021. "A water rule that turns a blind eye to transboundary pollution." *Science* 372 (6539): 241–3.

Magill, Bobby. 2021. *South Carolina Town's Growth Seeks to Outrace EPA Waters Rule.* https://news.bloomberglaw.com/environment-and-energy/south-carolina-towns-growth-seeks-to-outrace-epa-waters-rule.

Radeloff, Volker C., David P. Helmers, H. Anu Kramer, Miranda H. Mockrin, Patricia M. Alexandre, Avi Bar-Massada, Van Butsic, et al. 2018. "Rapid growth of the US wildland-urban interface raises wildfire risk." *Proceedings of the National Academy of Sciences* 115 (13): 3314–3319.

Ramani, Arjun, Joel Alecdo, and Nicholas Bloom. 2024. "How working from home reshapes cities." *Proceedings of the National Academy of Sciences* 121 (45): e2408930121.

Shapiro, Joseph S., and Reed Walker. 2024. "Is Air Pollution Regulation too Lenient?" NBER Working Paper 28199.

Stavins, Robert N., and Adam B. Jaffe. 1990. "Unintended Impacts of Public Investments on Private Decisions: The Depletion of Forested Wetlands." *American Economic Review* 80 (3): 337–352.

Sullivan, S Mažeika P, Mark C Rains, Amanda D Rodewald, William W Buzbee, and Amy D Rosemond. 2020. "Distorting Science, Putting Water at Risk." *Science* 369:766–768.

Sunding, David, and David Zilberman. 2002. "The economics of environmental regulation by licensing: An assessment of recent changes to the wetland permitting process." *Natural Resources Journal,* 59–90.

Taylor, Charles A, and Hannah Druckenmiller. 2022. "Wetlands, Flooding, and the Clean Water Act." *American Economic Review* 112 (4): 1334–63.

Turner, R Kerry, Jeroen CJM Van Den Bergh, Tore Söderqvist, Aat Barendregt, Jan Van Der Straaten, Edward Maltby, and Ekko C Van Ierland. 2000. "Ecological-economic analysis of wetlands: scientific integration for management and policy." *Ecological economics* 35 (1): 7–23.

Walker, Reed. 2013. "The Transitional Costs of Sectoral Reallocation: Evidence from the Clean Air Act and the Workforce." *Quarterly Journal of Economics* 128(4):1787–1835.

Zellmer, Sandra. 2013. "Treading Water while Congress Ignores the Nation's Environment." *Notre Dame Law Review* 88 (5): 2323.