NBER WORKING PAPER SERIES

# THE COST OF SPECIES PROTECTION:
# THE LAND MARKET IMPACTS OF THE ENDANGERED SPECIES ACT

Eyal G. Frank
Maximilian Auffhammer
David McLaughlin
Elisheba Spiller
David L. Sunding

Working Paper 33352
http://www.nber.org/papers/w33352

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
January 2025

We thank Sushant Banjara, Sara Gerstner, Simon Greenhill, and Wei Guo for excellent research assistance. We are grateful for helpful comments from Koichiro Ito, Ryan Kellogg, Joseph Shapiro, and seminar participants at the University of Wisconsin-Madison, UC Berkeley, UC San Diego, Environmental Defense Fund, AEA AERE Biodiversity session, Hebrew University of Jerusalem, NBER EEE SI, Toulouse School of Economics, the University of Connecticut, Woods Hole Oceanographic Institution, and Paris School of Economics. We thank the Becker Friedman Institute and the Fama-Miller Center for Research in Finance at the University of Chicago for providing CoreLogic data access. This research is funded by the Becker Friedman Institute at the University of Chicago and the Giannini Foundation. Finally, we are grateful to the staff at the US Fish and Wildlife Service for assisting us with accessing data. Please send any questions to the corresponding author at eyalfrank@uchicago.edu. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

The Cost of Species Protection: The Land Market Impacts of the Endangered Species Act
Eyal G. Frank, Maximilian Auffhammer, David McLaughlin, Elisheba Spiller, and David L. Sunding
NBER Working Paper No. 33352
January 2025
JEL No. Q24, Q28, Q57, Q58

**ABSTRACT**

Protecting species' habitats is the main policy tool employed across the globe to reduce biodiversity losses. These protections are hypothesized to conflict with private landowners' interests. We study the economic consequences of the most extensive and controversial piece of such environmental legislation in US history—the Endangered Species Act (ESA) of 1973. We assemble the most comprehensive data on species conservation efforts, land transactions, and building permits to date. By comparing parcels with identical histories of protections we show that, on average, the ESA shifts transactions from inside to outside of the protected area and leads to a slight appreciation in residential and vacant land values outside of critical habitats. We also show that the federal regulator determines borders for areas with the most stringent protections to avoid large effects on land values, only where it is explicitly allowed to take economic criteria into account. These average findings mask significant heterogeneity at the species and location level, which we document. Furthermore, we find no evidence of the ESA affecting building activity as measured by construction permits. Overall, even taking into account species-level heterogeneity, the number of possibly negatively affected parcels is extremely small. This suggests that the capitalization of the economic impacts of the ESA through the land market channel are likely minor, despite potential delays to development through permitting, for which we provide suggestive evidence. Our findings do not rule out economically significant impacts in a few highly constrained land markets with ESA protections amplified by local regulatory action.

Eyal G. Frank
Harris School of Public Policy
Univerity of Chicago
1307 E. 60th Street
Chicago, IL 60637
and NBER
eyalfrank@uchicago.edu

Maximilian Auffhammer
Agricultural and Resource Economics Department
University of California, Berkeley
207 Giannini Hall
Berkeley, CA 94720-3310
and NBER
auffhammer@berkeley.edu

David McLaughlin
Environmental Defense Fund
123 Mission St, 28th Floor
San Francisco, CA 94105
dmclaughlin@edf.org

Elisheba Spiller
Resources for the Future
1616 P St NW
Washington, DC 20036
bspiller@rff.org

David L. Sunding
University of California, Berkeley
207 Giannini Hall
Berkeley, CA 94720-3310
sunding@berkeley.edu

A data appendix is available at http://www.nber.org/data-appendix/w33352

# 1 Introduction

Monitored population sizes of mammals, birds, fish, reptiles, and amphibians have dropped by an average of 68 percent over the past 50 years (World Wildlife Fund 2020). Out of the four million assessed species worldwide, roughly 25 percent are considered threatened and face extinction, often within decades (IPBES 2019). Although a certain degree of extinction is to be expected, current rates are estimated to be 2–3 orders of magnitude larger than what is considered natural (Barnosky et al. 2011; Dirzo et al. 2014; Pimm et al. 2014; Ceballos et al. 2015). Habitat loss is by far the most significant driver of extinction, as humans have altered 75 percent of the land surface on Earth (IPBES 2019). Hence, the protection of natural habitats advocated for by biologists and ecologists has become the most important policy tool globally to prevent species from following a path to extinction, especially as climate change is expected to increase pressure on habitats and extinction risk. An effort under the auspices of the United Nations is underway to double the area of protected land to 30 percent globally, relative to 2017 levels. Doing so, which entails imposing restrictions on development of both public and private lands, is being met with opposition from private landowners and developers, who are concerned about the potential effect on their land or property.

We examine the economic consequences of the 1973 US Endangered Species Act (ESA)—considered by some as the "most important US law protecting biodiversity" (Owen 2012)—which served as a blueprint for conservation legislation in Australia, Canada, Europe, Asia, and Latin America. It is also the most controversial federal environmental regulation (Shogren et al. 1999; List et al. 2006). Critics have raised concerns about costs imposed on private landowners, in terms of both lowering of property values and delaying development—resulting in claims that the ESA is the "strongest environmental law in the world" (Goble 2005).

The key contribution we make in this paper is to provide a comprehensive evaluation—going beyond the species-specific case studies that are common in the literature—of how land markets respond to the ESA protections. We do so by testing five specific hypotheses as to how the ESA may affect land markets. First, we study whether the observed *number* of land or housing transactions differs just inside versus just outside the border of the protected areas before and after the imposition of the two main types of ESA restrictions the US Fish and Wildlife Service (FWS) uses. Second, we test whether restrictions on land development in the biologically determined protected areas lead to changes in housing and land *values* for properties located inside, outside, and proximate to the border. Third, we are the first to explicitly test whether the act's most controversial aspect, the FWS designation of critical habitat (CH), has measurable impacts beyond those caused by the biologically determined species habitat (SH) listing. The FWS considers CHs as "areas of habitat believed to be essential to the species' conservation." It does not see designation as an additional level of protection, as it does not extend the scope or severity of the statutory protections already awarded by listing the species. However, in practice, it has been hypothesized that a CH designation highlights for local regulators where to focus their regulatory activity to minimize harm to species. Fourth, we test whether locally controversial listings or designations have measurably different effects relative to species and transactions in locations where there was no public controversy about the enactment of statutory protections. Fifth and finally, we examine whether the listing of a species under the ESA itself has a measurable effect on the frequency and timing of the issuance of building permits and habitat conservation plans. Importantly, we do not examine the direct or indirect value of biodiversity, as others have done (Frank 2024; Frank and Sudarshan 2024; Hanley and Perrings 2019; Weitzman 1992; Metrick and Weitzman 1998), or determine which species or lands should be protected, if one were to choose the boundaries of protected lands in an optimal fashion (Weitzman 1993).

To test these hypotheses, we assembled the most comprehensive dataset on the spatial extent and type of ESA land restrictions for more than 900 species in the contiguous United States, going back to the beginning of the act. To causally estimate the economic impact of the act, we matched these data using space and time identifiers to data on housing and land transactions (CoreLogic) that span five decades and cover all land markets. Our analysis uses staggered and spatial differences-in-differences research designs, where we use the uncertainty about the timing of when protections are awarded as a time series of shocks to local land markets. The key identifying assumption is that landowners are severely limited in anticipating when and where ESA protections will be awarded. By further adding significant data on species-level lawsuits, building permits from the Army Corps of Engineers (ACE), county-level construction permit Census data, and (for the first time in the literature) the nationwide individual building permits, we can go much beyond simply looking at housing prices and more fully characterize both the overall impacts of the ESA and their heterogeneity (e.g., by species, region, and outcome).

In what follows, we show evidence of six main findings. First, the number of sales in areas eventually designated as CH, perceived as the act's most stringent restriction, is massively lower than those just outside these areas—both before *and* after designation. This suggests that the FWS draws these boundaries by proactively taking into account local housing market characteristics, which it is permitted to do. We also show that this is not the case for the biologically determined SH designations. Second, we show that, on average, the effects of the ESA on housing prices inside versus outside of SHs and CHs are not statistically different from zero. For SHs, this zero is precisely estimated and persistent. For CHs, the effect is noisier, but we can rule out the much larger impacts found by some case studies. We observe these patterns even when focusing on the subsamples where treatment intensity is arguably higher and where we would expect larger impacts *ex ante*. Third, we show evidence of an appreciation in the value of homes within 2km *outside* of the CH boundary. The effect is precisely estimated, robust to sample composition, and consistent with increases in amenity value of being close to a now more protected area, in addition to higher predicted scarcity of housing supply due to growing land use restrictions. Fourth, we show substantial heterogeneity in land market impacts at the species level, suggesting the external validity of single species or market studies is severely limited. Fifth, using both aggregate and micro-level data on building permits, we show that the ESA does not appear to affect permitted building activity in more restricted land markets. Finally, we document and quantify the burden imposed on developers in terms of the length of habitat conservation plans and heterogeneity therein; for a small share of species, we find a significant increase in time between application and issuance of building permits.

## 2 Relevant Literature

There is a long history of papers examining the economic effects of federal environmental regulation on land markets (such as the Clean Air Act, Clean Water Act, and CERCLA "Superfund") (Currie and Walker 2019; Keiser 2019; Greenstone and Gallagher 2008) and beyond (such as the Weatherization Assistance Program, fuel economy standards, and fuel content regulation) (Fowlie et al. 2018; Ito and Sallee 2018; Auffhammer and Kellogg 2011). This paper focuses on the land market impacts of the ESA, a federal regulation that touches almost all public and private land in the lower 48 states.[1] The literature, which largely focuses on single species in specific locations, generally finds a negative impact of ESA restrictions on land and property values. However, we find no such evidence for an average treatment effect in our comprehensive examination.

For instance, Greenstone and Gayer (2009) report a small, negative impact on property values in plant-species-specific CH areas. Mamun et al. (2023) find that the average impact of CH on land values is not distinguishable from zero but show evidence of underlying heterogeneity. Auffhammer et al. (2020) and List et al. (2006) find negative impacts on vacant lands in CH areas. The effect on permit issuance is mixed; Zabel and Paterson (2006) note a decrease in CA, whereas Sims et al. (2019) find a positive but statistically insignificant impact in New England. Bahrami et al. (2024) study how protected areas, not exclusively due to ESA listings, affect vacant land prices from 2010 to 2020 and find a 45 percent decline in value. Our findings suggest limited external validity of species or

[1] With respect to the ESA, economists have studied various aspects of the act. See Brown and Shogren (1998) and Ando and Langpap (2018) for excellent reviews of studies on the ESA in economics.

location-specific studies, making it important to evaluate those studies in a broad context of treatment effect heterogeneity. Evaluations are limited of conservation policies at the national or continental scale, with work by Grupp et al. (2024)—who document how land protections in the European Union fail to increase green land cover—reflecting a notable exception.

In line with the literature, we find suggestive evidence that accords with the notion of pre-emptive development due to protected area designation. List et al. (2006) observe an increase in permit applications in CH areas prior to final designation. Similarly, Lueck and Michael (2003) report increased forest plot harvest probability in anticipation of protection. Additionally, Bošković and Nøstbakken (2017) find decreased oil lease auction values in protected areas in Alberta, Canada. This literature indicates negative economic impacts of protected areas on local economies.

Our study also relates to literature on land use and housing regulations' effects on property values (Turner et al. 2014). Generally, land-use regulations increase property values by restricting housing supply (see Quigley and Rosenthal (2005) for a review) and raising construction costs (see Glaeser and Gyourko (2003), Glaeser et al. (2005), and Quigley and Raphael (2005)). Our research examines the effect of proximity to protected areas on housing prices. Given restricted housing supply within protected areas, we might expect higher property values nearby. Conversely, values within protected areas could decrease due to increased construction costs.

Protected areas not only restrict supply but also provide green, open spaces that enhance nearby property values (see McConnell and Walls (2005) and Reeves et al. (2018)). Conversely, proximity to developed areas can affect property values either positively (e.g., shopping malls; Zhang et al. (2019)) or negatively (e.g., fast food restaurants; Drewnowski et al. (2014)). Thus, our work identifies the combined effects of restricted housing supply, amenity value of open spaces, and reduced commercial activity on property values near protected areas. More broadly, previous studies have also documented how labor markets respond to area-based conservation that places land use restrictions (Ferris and Frank 2021; Szabó and Ujhelyi 2024), as well as drilling decisions for oil and gas (Melstrom 2017).

Methodologically, we contribute to the hedonics literature on capitalization of (dis)amenities into property values. Since Rosen (1974), the hedonics methodology has advanced significantly. New techniques include Tiebout sorting (Kuminoff et al. (2013)), semiparametric methods (Bajari and Benkard (2005)), and quasi-experimental approaches (Lucas W Davis (2004), Chay and Greenstone (2005), Kuminoff and Pope (2014), Muehlenbachs et al. (2015)). We use a quasi-experimental approach, leveraging the staggered rollout of ESA restrictions to identify their impact on property and land values.

# 3 The ESA & Restrictions on Private Property Development

The ESA was enacted in 1973 with a unanimous US Senate vote (Mann and Plummer 1995). Its stated purpose is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" (Endangered Species Act of 1973). Two federal agencies are responsible for listing species as either "threatened" or "endangered" and managing their recovery: the FWS and the National Marine Fisheries Services (NMFS).

Species gain protections under the ESA after either the FWS or NMFS conducts a review process and finds them "warranted" for protection. This process starts due to an internal review process, a petition by a third party, or a court ruling following an action-forcing lawsuit. The relevant agency issues a biological opinion based on "the best available scientific knowledge."

The agencies make two key determinations with regards to protecting a species' habitat: species *listings* and CH *designations*. Before a species can be protected under the ESA, it must be added to the federal lists of endangered and threatened wildlife and plants. A species is included in the list, or listed, once it is determined to meet the act's definition of endangered or threatened. The listing is a function of the scientific review alone, which is conducted by wildlife biologists at the agencies. Economic factors cannot be taken into account at this stage.[2]

When a species is proposed for listing as endangered or threatened under the ESA, some receive a CH designation for all or some of the biological habitat—the SH. Areas of the SH that are designated as CHs are specific areas that are deemed essential for the conservation of an endangered species. These designations might lag, often by years, after the listing. They cannot, however, preempt a listing. Also, all CHs are a subset of the SHs. We use the terms *listing* and *designation* to refer to these two tools available to the agencies under the ESA.

The ESA provides regulatory tools to restrict any actions that can jeopardize the survival of a species, without the need to first demonstrate a favorable cost-benefit comparison — a result of key words left out of the legislation, which led the US Supreme Court to interpret that the act aims to prevent extinction at "whatever the cost" (Mann and Plummer 1995). Section 9 of the act does, however, contain a provision exempting persons (e.g. landowners and developers) from its restrictions if compliance would cause "undue economic hardship."

The regulatory power of the ESA arises primarily from Section 7, which requires federal agencies to consult with the FWS and NMFS to ensure that their activities will not adversely affect listed species or their CHs. Specifically, Section 7(a)(1) of the act asserts that the process is meant to ensure that federal agency actions and private actions with a federal nexus, those requiring federal approvals, permits, or funding, are "not likely to jeopardize the continued existence" of a listed species or adversely modify habitat that is important for its survival. Before proceeding with the action, the agency must determine whether any listed species may be present and affected.

Section 7 frequently impacts real-estate development projects, resulting in restrictions and costs on private land. For example, if development is slated for land containing wetlands,

[2] See Online Appendix B for more information on the listing process and sections of the ESA.

then the developer must obtain a discharge permit from the ACE under Section 404 of the Clean Water Act. If the wetland contains endangered SH (e.g., California vernal pools, red-legged frog), then the ACE must consult with the FWS before issuing a discharge permit. The ACE can only issue a permit once the planned development has been modified to satisfy the FWS that the listed species are not adversely impacted.

Concurrently with listing a species, Section 4(a)(3) of the ESA requires the Secretary of the Interior or Commerce—"to the maximum extent prudent and determinable"—to designate its CH. These contain physical or biological features *essential* to the conservation of the species and may require special management or protection. CH determinations must be based on the best scientific data available and can account for *economic effects*, effects on national security, and other relevant effects. As a result, Section 4(b) allows the Secretary to remove areas from CH if the biological benefits are outweighed by the economic costs.

The ESA can impose costs on project developers on private land through the anti-take provisions of Section 9. A 1995 ruling by the Supreme Court established that the definition of "harm" in the ESA can include habitat modification or alteration (Powell 1995). Thus, when listed species are present, the ESA forbids developers from significantly modifying or degrading habitat where it actually kills or injures wildlife, directly or indirectly. In practice, this prohibition requires developers to reduce the scale of their project, move its location, or redesign it, such as through densification in a way to reduce the negative impacts on species. All of these actions may create additional costs through direct outlays, reduced revenues, project delays, and additional uncertainty.

Reviews by legal scholars of the ESA have determined it does not prohibit land development, as some critics argue. Houck (1993) summarizes that "there is no evidence that formal consultation under the Endangered Species Act is stopping the world. Little evidence shows that it is changing it very much at all." In reviewing 4,048 biological opinions spanning 2005 to 2009, Owen (2012) finds that agencies and regulated entities benefit from the multiple opportunities to modify their plans such that they can avoid a jeopardy or adverse modification determination. In fact, only 7.2 and 6.7 percent of the 4,048 biological opinions result in jeopardy or adverse modification determinations, respectively.

Designations can impose incremental costs beyond those associated with listings. A designation is highly controversial, and as Shogren et al. (1999) write, “private parties seek not to have their lands designated in this way.” Houck (1993) notes that it is a “red flag to the development community and that community’s representatives in Congress.” Beyond the formal mechanisms established by the ESA, designation can be a signal to local regulators where habitat protections should be prioritized and impacts avoided. Local land-use authorities in theory have wide latitude to restrict or modify land development projects and can alter requirements on the basis of a CH designation. Interviews with 15 FWS and NMFS biologists reveal that they mostly think of designations as improving the negotiating power of the agency and that they make the other federal agencies and regulated entities “take the ESA a little more seriously” (Owen 2012).

# 4 Conceptual Framework on Land Markets & Statutory Protections

The ESA may impact property and land values via a multitude of channels, across both time and the type of property affected. Figure 1 breaks down the effect of ESA actions (listing or designation) by stage (after the proposed and after the finalized rule), location (inside versus outside the protected area), and whether the affected transaction is for a residential property versus for a vacant land. This leaves eight different equilibrium adjustments for each of the two actions. Figure 1 summarizes the main predictions regarding the supply and demand of residential properties and vacant lands following either action.

In general, changes to the supply in each stage and market are unambiguous. For example, after a rule is proposed but not yet finalized, properties might be pre-emptively developed or vacant land may have a “fire sale,” both shifting out the supply curve. After the rule is finalized, development costs are higher, and supply shifts in for residential properties. The direction of the shift is *ex ante* clear. On the demand side, however, the direction is ambiguous, creating uncertainty in the predictions regarding the overall effect. For example, after the finalization of a rule on residential properties, current or future property owners might enjoy the likelihood of greater open space and less development, which would shift out demand. Alternatively, property owners or prospective buyers could be worried about possible complexities in being able to modify their property and the associated costs, which might shift in demand. Hence, in summary, as the demand effects are ambiguous both inside and outside of the residential property areas after the proposal and finalization of protections—the sign and magnitude of the equilibrium effect cannot be clearly determined *ex ante*. Overall, for the combined net effects, theory predicts that prices for vacant lands will go down *inside* the protected area but up *outside* of it. Because of the ambiguity in the demand response for residential properties, we cannot fully determine the net effect *ex ante*. In Online Appendix C, we provide a detailed interpretation of each subpanel in Figure 1.

# 5 Species Listings, Property Values & Permits Data

Our goal is to generate a comprehensive estimate of the impacts of the ESA on land markets, for the contiguous United States, spanning the years 1976–2019. We bring together data on all the ESA species-level events that can lead to or form expectations of land-use restrictions. We combine the precise ESA location data on biological and CHs with geocoded land and housing transaction data. Furthermore, we are the first in this literature to be able to add precisely geocoded permits for new construction. Our focus is on species whose habitats are, at least in part, terrestrial—meaning we exclude solely aquatic species (e.g., fish and crustaceans). In addition to the regulatory steps that award statutory protections to species, we add data on petitions submitted to the FWS and lawsuits against the FWS that seek to force it to list a species or designate CHs for a listed species.

To better account for variation in treatment intensity under the ESA, we collect additional data generated at the time of the listing and the observed workload the species has generated for the FWS. For each species, we obtain the Recovery Priority Number (RPN, which codifies the degree of threat, recovery potential, and taxonomic distinctness) and its classification for posing a conflict with land development. We further collect data on the consultations the FWS has for each species, under Section 7 of the ESA (see Section 3 for more details).

We examine additional channels through which the ESA could affect land markets by collecting data on a variety of permits directly connected to land development. We collect data on building-level new construction permits, county-level construction permits, permits from the ACE that ensure the land development complies with both the Clean Water Act and ESA, and the development of Habitat Conservation Plans that allow a developer to obtain an incidental take permit (see Online Appendix B for more details). In this section, we briefly summarize each dataset and provide a detailed account of how we obtained them. In Online Appendix D, we provide further details on each data item and ample information on data processing. We summarize the key variables used in the analysis in Table D1. Overall, this is the most extensive dataset related to the ESA ever constructed in terms of depth of information as well as temporal and spatial scale.

**Listings and Designations:** The ESA provides us with multiple time series of local shocks to land markets. Since its enactment in 1973, almost every year has seen at least one proposal or decision to list a species or designate a CH. We construct the full history of Proposed and Final Rules by first using the FWS Species Data Explorer API. Unfortunately, the API offers incomplete information on dates, so we fill in missing date and event information by manually reviewing the publications in the Federal Register.

The timing of the listings is staggered and often concentrated in small batches, so several species receive their proposed and final rules on the same day. We interpret this pattern as an indication of some degree of uncertainty regarding the exact timing of when ESA restriction might apply. See Figures 2a and 2b for a summary of the time between a proposed and final rule for each species.

**Habitat Definitions:** The phased introduction of land-use restrictions applies to certain localities but not others, depending on the geographic extent of the species' habitat. The FWS has maps that delineate the habitat ranges and CHs for the listed species, which we have obtained, processed, digitized, and matched to the listing and designation dates. We use these to define the treated areas. See Figures 2c and 2d for the areas that were under some form of ESA statutory protections by decade, for either listings or designations. In some cases, when species are delisted, the spatial information regarding their habitat or CH is no longer available in the main FWS repository. In other cases, the CH (but not the SH) might undergo revisions. To address these issues, we use previous snapshots of the FWS habitat repository or construct them manually from information available in the Federal Register. See Online Appendix D for a full description of this process.

**Lawsuits and Petitions:** The decision to list a species or designate CHs may follow a petition submitted to or a lawsuit filed against the FWS. We filed a FOIA request to extend the data on lawsuits against the FWS from Langpap (2022) to cover those filed from 1988 until 2019. In addition, we also manually classified each lawsuit as either supporting or opposing additional conservation measures. For example, a lawsuit could be filed to list a species that the FWS has decided is unwarranted for protection (supportive) or challenge the boundaries of a CH (opposing). Using a similar process to the one we use to obtain the date for the listing and designation rules, we also collect the date for petitions, which are used by non-government actors to initiate a formal review of the conservation status of a species by FWS.[3]

[3] For more details about the petition process, see this excellent one-page summary: https://www.fws.gov/sites/default/files/documents/endangered-species-act-petition-process.pdf. Accessed 5/13/2024.

**Recovery Priority Numbers & Section 7 Consultations:** We seek to account for land-use restrictions heterogeneity by using proxies for locations or species with "high treatment intensity." We obtained, through two separate FOIA requests to the FWS, data at the species level on the Recovery Priority Numbers (RPNs) and the number of consultations submitted to the FWS. When listing a species, the FWS assigns an RPN, ranging from 1 to 12, that combines information about three main categories, in lexicographic order: extinction threat, recovery potential, and evolutionary uniqueness.[4] Each RPN can include a flag for potential conflict with economic activities, namely, land development, that might arise from listing.[5] We use the data to classify species as "ever conflict" if they ever had a conflict flag in our data. In addition, since 2008, the FWS stores all the consultation requests, filed under Section 7 of the ESA, in the Tracking and Integrated Logging System (TAILS) database. We match each consultation to the species and construct a measure of the number of total consultations received by the FWS since 2008. Combined, we consider two groups of species as potentially experiencing more binding land-use constraints: those that ever had a conflict flag or have an above-median number of FWS consultations.

**Property Transactions:** We obtained transactions data from the CoreLogic Tax and Deed Data. This dataset provides, at the transaction level, the exact location, date of sale, and sale price— allowing us to classify transactions as occurring during the pre-treatment or posttreatment period and inside or outside the protected area. Our main outcome of interest is the sale price. However, the data also allow us to examine the volume of transactions within distance bins outside and inside the affected area as an additional outcome. See Online Appendix D for additional details on coverage and processing of the CoreLogic data.

[4] Given that we have data after to 1983, the year that the FWS began assigning RPNs to species, 6 percent of the species do not have an RPN.

[5] The process is discussed in detail in the Federal Register publication https://archives.federalregister.gov/issue_slice/1983/9/21/43096-43105.pdf#page=3. Accessed 5/13/2024.

**Land Development Permits:** Land-use restrictions under the ESA could make it harder to obtain a construction permit. To study the potential effects on housing supply through the permitting channel, we collected data on various land development permits. We obtain county-level data on new residential construction permits as collected by the US Census Bureau's Building and Permits Survey (BPS) and complement these with geocoded permits by the ACE and geocoded new construction permits we purchased from BuildZoom. Finally, we obtain data on Habitat Conservation Plans (HCPs). When analyzing data at the county level, to capture undevelop ed parcels' average exposure to protected lands, we aggregate CH and SH area within a county using population weights. We also calculate the unique protected area in the county to avoid double-counting protected land covering multiple species.

# 6 Estimating the Impacts of the ESA on Land Markets

Our goal is to estimate the economic impacts on the market value of a parcel of land that are caused by the proposed rule to list or designate under the ESA—separately for residential and vacant lands. In an ideal setting, one would randomly assign protected status to habitats for endangered species across space and time—mimicking a randomized controlled trial. This is clearly not feasible in practice, as habitats are proposed and possibly assigned via a lengthy regulatory process, as discussed in Section 3. This complex process commences with information emerging about a species' possible high extinction risk without statutory protections. The exact timing of when that process starts, and whether and when a species moves forward in the process into a proposed or final rule, is uncertain. But of key importance to this paper is that it is not easy for individual private landowners to predict or manipulate that process, as our research design relies on the assumption that the timing of listing and designation rules are plausibly exogenous to actions of land market participants—this allows us to recover the causal impact of listing and designation on home values.

Our empirical approach to identify the economic impacts of the ESA compares properties on both sides of the spatial boundaries of either SH ranges or CHs, before and after their listing or designation, respectively. We define the treatment as both the ESA-induced timing of the change in land-use restrictions and the distance to the border. This flexible approach allows us to test whether the effect of the listing or designation affects properties fully contained inside the habitats differently than those outside the borders. Statutory protections that restrict land use can spill over to properties outside the protected area. These indirect effects can operate in opposite directions to one another (see Section 4 and Online Appendix C for a discussion of the mechanisms that affect land prices following land-use restrictions). As a result, we allow the impact on parcels to vary by distance to the border, thus capturing heterogeneous effects by distance to the newly imposed restrictions.

When estimating the effects of ESA protections, we pay careful attention to the onset of treatment and the distance bandwidth around the border that defines the sample. Protections for species are awarded through multiple ESA events related to the proposal and finalization of statutory rules, which could affect the market's valuation of individual parcels. Consequently, four periods can be considered as the beginning of treatment: the proposal or finalization of a species' listing or designation. In addition to the proposed and final rules, land markets can already respond to information from petitions to the FWS to extend protections to species or lawsuits that seek to force the FWS to take action (see Sections 3 and 5 for more details on the institutional details and data on petitions and lawsuits).

Just as each step of the ESA process over time can have a differential treatment effect, the effect on properties can change based on their location relative to the border of the protected area. Inside it, statutory protections apply equally. However, properties outside of it are only affected *indirectly* (e.g. via the increased likelihood of decreased development in bordering areas inside the protected area). In the analysis, we focus on properties that are within 10km of the border.

We showcase these temporal and spatial dimensions of ESA statutory protections by summarizing how land markets responded in the case of the protections awarded to the *pygmy owl*. This case demonstrates that multiple events can provide information to land markets regarding future land-use restrictions. This case study is also helpful because List et al. (2006) have documented that land markets were highly responsive to its CH designation. In Figure 3, we plot the moving average of the ratio of sale prices inside versus outside the protected area and how these ratios changed over time given the owl's listing and designation. We also report the mean sale price separately for inside and outside the protected area. For SH, we observe high price volatility up to the mid-1990s, likely driven by the small number of transactions in the data. Following the proposed listing rule in December 1994, we observe a steady decline in the ratio of residential prices, which plateaus after the final designation of CH in July, 1999. For CH, we see a similar decline in the ratio of prices following the proposed listing around the *yet-to-be-announced* border. This suggests that land markets are able to predict where the FWS will draw the border. In both habitat types, the decline in the ratio of the prices appears to be due to the prices increasing *outside* of the protected area rather than the prices inside declining. After the species was delisted, we see prices inside the CH diverging sharply from those outside. In summary, this case study is helpful in documenting the various potential definitions for treatment onset and the importance of examining where prices are changing around the border and in what direction.

Throughout the analysis, we hold the definition of the pretreatment period constant but consider different definitions of treatment onset in Online Appendix A. We regard the pretreatment period as the time before any proposed rule to list or designate. The onset of treatment is defined as the first date that a proposed listing rule is published. This allows us to test whether proposal has a statistically different impact, if any, from finalization. To identify the effect of the different stages of ESA protection, we always compare the posttreatment set of parcels to the pretreatment set, dropping the "in-between" parcel transactions.

In the main analysis, our focus is on the treatment effect of the proposed rules to either list or designate. This means that when we examine the treatment effect of listing, the pretreatment period (before the proposed rule) proceeds continuously into the posttreatment period (after the proposed rule). However, when we examine the treatment effect of the CH, the posttreatment period (after the proposed designation) might take place *after* the proposed or final listing rule. To focus on the treatment of interest—proposed CH designation—we drop parcel transactions between the date of the proposed listing and the date of the proposed designation. This allows us to cleanly compare pre- and post-event for each of the individual stages of ESA protection. We summarize the research design in Figure 4.

In summary, we study the net effect of ESA regulations on land markets using three techniques. First, we employ a staggered difference-in-differences (DD) design, where we compare the transaction values of properties inside and outside and before and after a listing or designation. This leverages the rollout in protections over time and relies on the uncertainty regarding the exact timing of the enactment of protections. Second, we conduct a spatial DD, comparing transactions in distance bins around the border of the protected area, before and after the listing or designation. This allows us to determine whether any observed price differences before and after the treatment onset are driven by depreciation or appreciation, inside or outside the protected area. Third, we use variation in the amount of land under ESA statutory protections to examine changes in various types of construction permits.

Throughout our analysis, our key identifying assumption is that the ESA actions, determined at the federal level, act as plausible exogenous shocks to local land markets. We also assume that in the absence of ESA regulations, land values and construction permits inside and outside the protected areas would have developed along parallel trends.

We need to consider two main potential confounders in terms of the bias they might introduce to the analysis. One is that land development results in habitat loss, increasing the probability of a species listing. In addition, land development might have a negative effect on prices or price growth due to increased supply. Combined, we can sign the effect of this confounding element to have a negative bias, resulting in attenuated estimates. If land development that occurs pre-ESA protection is truly a meaningful confounder in this setting, then we should expect to observe pretrends when estimating a staggered DD specification. The second relates to the designation of CHs. The FWS can take into account economic factors when deciding which parts of the SH to designate (though it cannot do so for the listing decision). This means the FWS might not designate highly valuable lands. If so, which is very plausible, then we are recovering a lower bound of the effect, as the highest-value transactions are not affected.[6] However, the FWS has repeatedly claimed that any observed economic effect would be solely due to listing, an argument we can empirically test using the data on SH and listing timing.

## 6.1 Main Regression Specifications

### 6.1.1 Staggered DD

We use the natural logarithm of the transaction price, ln(Sale Price$_{(i)(t)}$), where property $(i)$, denotes the physical location of the property with indices ZCTA5 $z$, in county $c$, in state $s$, in FWS region $r$, with distance $d$ to the border $b$; and transaction time $(t)$ denotes the year $y$ and month $m$.[7] The use of a two-way fixed effect estimator is appropriate in this setting, despite the staggered treatment, because of the large group of never-treated observations (Borusyak et al. 2024).[8] The DD specification estimates the effect of enacting

[6] Because climate change is expected to accelerate species loss, increase threatened species, and change migratory patterns, the ability of the FWS to avoid high-cost areas may decrease, potentially causing the cost of the ESA on land markets to increase.

[7] A ZCTA5 is an area defined by the Census Bureau, roughly equivalent to a five-digit ZIP code.

[8] Staggered DD methodologies are frequently used in economics (Autor 2003; Stevenson and Wolfers 2006; De Janvry et al. 2015; Alacevich et al. 2021). More recent literature has identified concerns with common staggered DD methods. The primary concern is that the two-way fixed effect estimator is a variance-weighted average of treatment effect parameters and, given heterogeneous treatment effects, can produce negative weights, resulting in incorrect estimates of the average treatment effect. Methods to diagnose negative weights in a staggered DD setting have been recently explored (Goodman-Bacon 2021), and estimators robust to heterogeneous treatment effects have been proposed by Sun and Abraham (2020), Callaway and Sant'Anna (2021), De Chaisemartin and D'Haultfœuille (2020a), and De Chaisemartin and d'Haultfoeuille (2020b). However, as Borusyak et al. (2024) discuss, a large control group negates the issues that the recent literature has raised. The key intuition is that with many never-treated units, those are sufficient to estimate the temporal fixed effects, and any unwanted comparisons between late- and early-treated units receive a very small weight in the estimated average treatment effect.

ESA protections on properties inside relative to those outside the protected area, before and after the event of interest:

$$\ln(\text{Sale Price}_{(i)(t)}) = \sum_{\substack{\tau \in \{\underline{T},\ldots,\overline{T}\} \\ \tau \neq -3}} \mu_{(i)\tau}(\pi_\tau + \beta_\tau \omega_{(i)}) + \omega(\text{Inside})_{(i)} + \phi_z + \rho_{yr} + \eta_{mr} + \alpha_b + \boldsymbol{X_{(i)(t)}\theta} + \varepsilon_{(i)(t)} \quad (1)$$

The specification in Equation (1) estimates the dynamic development of transaction prices for properties inside versus outside the protected area. The evolution of the treatment is estimated by including leads and lags, in the form of $\mu_{(i)\tau}$, that equal one when the transaction is $\tau$ quarters from the event of interest. We set the omitted category to be *three* quarters away from the end of the pretreatment period—proposed listing rule—to make it easier to test for any anticipatory effects. We include two sets of leads and lags to test for the differential effect on properties inside. We interact them with $\omega_{(i)}$, a dummy variable that equals one when the property is inside the protected area. The set of coefficients, $\beta_\tau$, measure the dynamic development of transaction prices that is different for properties inside the protected area, whereas the set of coefficients $\pi_\tau$ measure how prices change over event time for properties inside and outside of it. The dummy variable, $(\text{Inside})_{(i)}$, equals one for properties that are ever inside the habitat and zero otherwise. Including this dummy variable allows us to absorb any pooled and time-invariant features shared across protected areas.

We are interested in isolating the residual variation that is not explained by baseline characteristics or pooled time effects. To account for time-invariant properties in land markets, we include fixed effects for ZCTA5, $\phi_z$. This controls for any areas that are predominately more rural relative to urban or have higher development opportunities and helps mitigate the omitted-variable bias by controlling for unobservables at a very localized level.[9] To flex-

[9] Kuminoff et al. (2010) demonstrate how including spatial dummies in a DD framework improves the

ibly control for time trends, we include sample year-by-FWS region fixed effects, $\rho_{yr}$.[10] To account for seasonality in land markets, we include calendar month-by-FWS region fixed effects, $\eta_{mr}$. The fine-scaled time fixed effects allow us to more accurately capture real business cycles or changes in local conservation efforts and legislation. To better compare across listings and designations, we also include a species fixed effect, $\alpha_b$.

Larger and newer properties will likely sell for higher prices. We control for this by including a set of property characteristics, $\boldsymbol{X_{it}}\theta$. Specifically, we include quintiles for the parcel area size (relative to the global distribution of parcel size) and include fixed effects for the total number of rooms (bedrooms and bathrooms) and construction year of the property. Any unobserved heterogeneity is captured by the error term, $\varepsilon_{(i)(t)}$. We cluster the standard errors at the ZCTA5 level and examine how different levels of clustering affect the precision of the estimates in Online Appendix A.

#### 6.1.2 Spatial DD

Property prices might develop differently after the enactment of statutory protections, and those changes might not be uniform with respect to distance from the border of the protected area. Our paper adds to a long literature using a spatial DD approach (Kiel and Zabel 2001; Currie and Walker 2011; Lucas W. Davis 2011; Linden and Rockoff 2008; Bento et al. 2015; Muehlenbachs et al. 2015; Albouy et al. 2020; Diamond and McQuade 2019), whereby the effect of treatment varies with distance to the (dis)amenity or regulation. We modify the specification in Equation (1) to focus on changes in distance bins of 1km before and after treatment onset. To allow for including any potential anticipatory effects in the treatment period, we classify the two quarters before the proposed rule as part of the treatment period. We allow the effect to vary up to 10km distance on either side of the protected border.

estimation of marginal willingness to pay in a setting with time differentiated data.

[10] The contiguous United States is divided into seven FWS regions: Northeast, Southeast, Southwest, Pacific Southwest, Pacific, Mountain, and Midwest.

$$\ln(\text{Sale Price}_{(i)(t)}) = \sum_{\substack{k\in\{\underline{k},\ldots,\overline{k}\}\\ k\neq k_0}} \lambda_{(i)}(\gamma_k + \delta_k \psi_{k(t)}) + \nu(\text{Post})_{(t)} + \phi_z + \rho_{yr} + \eta_{mr} + \alpha_b + \boldsymbol{X_{(i)(t)}\theta} + \varepsilon_{(i)(t)} \quad (2)$$

The spatial DD focuses on a set of distance bins, $\lambda_{(i)}$, instead of leads and lags. Each distance bin dummy equals one when property $i$ is located in distance bin $k$. We center distance at the border and measure distance from the border inside in negative values and distance from the border outside in positive values. As before, we include two sets of dummies, but this time for distance bins. The first set of distance bin dummies captures the average transaction price from the border as a function of distance, both before and after the potential enactment of land-use restrictions—captured in the $\gamma_k$ coefficients. The second set is interacted with a dummy, $\psi_{k(t)}$, that equals one when the transaction takes place after the onset of treatment. The coefficients of interest, $\delta_k$, measure how prices change around the border after the land-use restrictions apply. The dummy variable, $(\text{Post})_{(t)}$, equals one for time periods after the treatment onset and zero otherwise. This specification allows us to directly test for any violations of the stable unit treatment values assumption in the form of spillovers on the properties that are outside the border. All other variables are the same as in Equation (1).

#### 6.1.3 Two-Way Fixed Effects

The timing of a land transaction is another meaningful source of heterogeneity. As more events unfold, more information exists about the certainty of listing and how much the protections will be binding. We estimate a modified specification that focuses on the transactions 0–3km *inside* and 0–6km *outside* the protected area. We define separate event dummies and estimate their interactions with the distance bins using the following specification:

$$\ln(\text{Sale Price}_{(i)(t)}) = \sum_k \sum_e \psi_{ke}(\text{Distance}_k)(\text{After}_e) + \sum_k \kappa_k(\text{Distance}_k) + \sum_e \varphi_e(\text{After}_e) + \phi_z + \rho_{yr} + \eta_{mr} + \alpha_b + \boldsymbol{X_{it}\theta} + \varepsilon_{izcsdbym} \quad (3)$$

We define three distance bin dummies, $\text{Distance}_k$: one if the property is up to 3km inside the protected area and two more for properties outside of it, up to 3km and 3–6km. We define the event dummies, $\text{After}_e$, as equal to 1 if the transaction takes place after one of the following events: petition or lawsuit regarding the species, proposed listing rule, final listing rule, proposed designation rule, and final designation rule. Once the event occurs, the dummy variable switches from zero to one and maintains that value even as other events occur. Our interest is in the interactions of the distance bin dummies and the event dummies, captured by the set of coefficients $\psi_{ke}$. We also include the dummies for the distance bins and events, while excluding the dummy for the 3–6km outside the protected area, which serves as the omitted category. All other variables are the same as in Equation (1).

# 7 Main Land Market Outcomes Estimation Results

## 7.1 Transaction Counts

Before we turn to the analysis of how listing and designation impact the *value* of built-up and vacant parcels, we examine what happens to the *number* of transactions inside and outside of the SH and CH boundaries. In Figure 5, we summarize the number of transactions in 1km distance bins relative to the border of SHs and CHs, before the proposed (light) and after the finalized (dark) listing or designation event. For species listings, we observe slightly more residential property transactions after the finalized listing (dark line) relative to before the proposal (gray line) across all distance bins for residential (Panel a) and vacant lands (Panel c). Furthermore, we find no visible discontinuity in the number of transactions at the species border before or after for residential property and vacant land transactions. This finding is consistent with the requirement discussed in Section 3 that FWS cannot take into account nonbiological (e.g., economic) considerations when setting species boundaries.

We now turn to the case of CH designation, where a starkly different pattern emerges. First, a clear, sizable discontinuity at the border appears for both residential properties (Panel b) and vacant land transactions (Panel d) *prior* to proposed designation. It grows when we look at the transactions outside of the border after the finalized designation. The sharp discontinuity of transaction counts, with significantly fewer inside the CH area, is one of our most interesting findings. It is strong evidence that FWS takes housing market activity into account when drawing CH boundaries, which, as Section 3 discusses, it is allowed to do. The difference right at the boundary is economically and statistically significant, indicating a sixfold difference in sales in adjacent communities. See Figure A1 for estimation results using either the transaction rate or a dummy variable for nonzero transactions (to capture movement along the extensive margin).

## 7.2 ESA Impacts on Property Values: Species Habitats

We now turn to the average impact of the ESA on property values across species and start with the results for residential properties located near the border of an SH. The first set of results uses the staggered DD design from Section 6.1.1 with our most restrictive set of property transactions (those with nonmissing data on parcel size, number of rooms, and year of construction). In Panel (a) of Figure 6, we demonstrate that properties within SHs sell for the same average price before and after the determination of SHs, compared to properties located up to 10km away—when comparing properties sold two years before and after the proposed listing. This effect is precisely estimated, and we can rule out even small economically significant estimates.

Although the staggered difference approach allows us to recover what happens to the value of properties inside relative to properties outside the SH, it does not allow us to recover what happens to the level of prices inside and outside the border—only their difference. We hence now turn to the spatial DD approach discussed in Section 6.1.2, which allows us to estimate what happens to prices by distance from the border. Panel (c) in Figure 6 displays our estimated effects using the same sample as in Panel (a). Relative to the excluded bin of 5km outside the border, we see no statistically significant differences in property values from listing, except for a small and statistically significant decrease 10km inside the habitat, which is based on less than 1 percent of the observations.

As in Panel (a), our sample in Panel (c) includes transactions that have taken place only two years before the proposed listing or two years after the final listing. In Panel (e), we expand our sample to include transactions to those that happen within five years of the listing, which we believe to be a worthwhile comparison, as land markets adjust slowly due to permitting and the general duration of new construction. Expanding our sample amplifies some of the patterns we found using the more restricted sample. We see a marginally statistically significant drop in residential property values from just inside to 5km inside the habitat border. We can rule out the very large effects that some of the papers cited in the literature review find. On the outside, we see a slight appreciation 8–10km outside the SH. This appreciation is not large but statistically significant. This is consistent with buyers perceiving listing as an improvement in amenity value or a policy-induced reduction in construction activity inside and near the SH border, which in turn pushed prices up in possibly more saturated markets further away from the border.

The treatment intensity of the ESA is not necessarily equal across listings, potentially masking meaningful impacts on sale prices in Figure 6, as those results represent average effects across all types of transactions. In Figure 7, we break down the estimation for different types of transactions by whether they were "ever conflict," "high ACE permits," or "high FWS consultations," as defined in Section 5. Due to sample size limitations for subgroups, all results in the subgroup analysis use the larger sample of five years pre- and post-listing, which also allows us to capture longer-term effects. For all three subgroup analyses, the pattern is almost identical to that for the full sample shown in Figure 6c. For the "ever-conflict" subsample in Figure 7a, we do not see a statistically different effect of listing for any of the bins. We next turn to Panel (b), where the pattern for the "high ACE permit" sample is essentially identical to the overall results, with negative yet not statistically significant effects inside the listed area and positive and significant appreciation of values in the 8–10km bin outside the listed area. The most pronounced difference from the overall sample comes from the "high FWS consultations" subsample. We see negative and statistically significant point estimates for the first two bins inside the listed area (and the 6km bin) and statistically significant appreciation in the 8 and 9km bins outside the listed area. This suggests that species that draw more regulatory attention from the FWS might lead to small but measurable decreases in housing value inside the species border in more contested land markets.

A sample of repeated sales has the clear benefit of allowing us to focus more narrowly on the residual variation within each property, from before to after ESA protections are imposed. However, we are severely limited by the data, as even in the case of SHs, the sample size of the repeated sales samples is two orders of magnitude smaller than the baseline sample—making any estimation using this sample severely underpowered. Unsurprisingly, we fail to detect any changes in sale prices, on average, around the border of SHs when using repeated sales, even when allowing for different treatment onsets (see Figures A20–A22).

All the results so far have focused on residential property transactions, which is land with built structures on it. The CoreLogic data also contain sales data for vacant lands, which we classify into "residential" and "nonresidential." The former has additional flags in the data that suggest residential zoning or development potential but no built structures. The latter could be agricultural or commercial/industrial. Figure 8 repeats the estimation underlying Figures 6 and 7 but for vacant lands, separated into residential and nonresidential. Panel (a) shows the effects for listing by distance bins for 83 species and about 225,000 residential vacant land transactions. Broadly, we fail to observe any statistically significant effects on land values inside or outside of the listing boundary. The effects for the "ever-conflict" subsample shown in Panel (b) are identical, but the sample size is cut in half.

Results for nonresidential vacant lands suggest larger effects for "controversial" species listings, yet interpretation and precision are limited by a smaller sample size. Figure 8c shows an imprecisely estimated "zero effect" across almost all bins. The "ever-conflict" subsample only has about 50,000 observations in it, and the estimation results are extremely noisy. We see decreases in land values just inside and outside the boundary, which are statistically significant and large, further stressing the limits to external validity of single species or land market studies that dominate the literature.

## 7.3 ESA Impacts on Property Values: CHs

We next turn to estimating the impact of CH designation on property values. These regressions drop transactions that occur between proposed listing and proposed designation (as described in Figure 4), and hence these results reflect the long-run impacts of listing. We include these transactions and discuss additional sources of heterogeneity in the next section. In Panel (b) of Figure 6, we fail to reject that properties that are sold inside CHs, up to 10km away from the border, sell for the same average price after the designation of CH as before relative to properties outside. The point estimates in the post period are uniformly negative. However, unlike for listing, this effect is much less precisely estimated. Yet we can rule out changes in prices larger than 15 percent—which is significantly smaller than what has been found in the single-species papers we reviewed.

The spatial DD approach highlights a fundamentally different pattern than the staggered DD estimation as prices change inside and outside of the CH. The first thing we note in Figure 6d is the insufficiently large number of observations inside the CH to power the estimation of all 10 bins inside. We have hence collapsed all sales further than 2km from the CH boundary into the 2km bin. We find no significant drop in property values inside the CH. However, a different picture emerges just outside the CH boundary, with evidence of a statistically and economically significant increase in property values within the first two bins. The point estimates for this increase are 6 and 5 percent, respectively, and we cannot rule out an increase of up to 10 percent for these two bins. This finding is strongly consistent with amenity value and scarcity channels, whereby properties in highly active housing markets improve knowing that development in their "backyard" just became more challenging. These findings are robust to expanding our sample to transactions five years before the proposed listing and five years after the finalized designation (Panel f). The distance bin approach hence highlights an important phenomenon: the relative price of parcels inside the boundary drops, but this is via not a depreciation effect on those parcels but an appreciation of those just outside. Research has until now only been able to identify the net effect; our paper sheds light on this important mechanism.

The main instance where we do observe meaningful and precisely estimated lower sale prices of about 10 percent inside CHs is when we focus on new construction of residential properties (Online Appendix Figure A9, see panels d and f). However, we are limited in our ability to interpret those results, as the sample size shrinks by an order of magnitude, and we only observe about a third of the species relative to the full sample.

In Figure 7, we break down the estimation for the different subgroups for CH designation. Again, due to sample size limitations, all results in the subgroup analysis use the larger sample of five years before and after listing. For the "ever-conflict" subsample in panel (d), we see a qualitatively similar pattern to the full sample, yet the appreciation just outside the designated area is no longer statistically significant.

In Panel (e), in the pattern for the "high ACE permit" sample, we see the most pronounced difference from the overall results. We now detect a statistically and economically significant decrease in value 2km inside the CH. Although the number of transactions inside the CH post designation is very small (less than 2 percent of the sample), we continue to see significant increases just outside the boundary (1–2km). For the "high FWS consultations" subsample in Panel (f), we see no statistically significant effects inside or outside of the boundaries. These results suggest that different treatment intensities are linked to potential location-specific constraints and how those operate through the federal nexus.

In Online Appendix Figure A7, we observe more evidence for the ability of land markets to correctly infer where the CH border will be designated. We observe this for a subset of species that might have higher treatment intensity and CHs are proposed for designation with a five-year delay relative to the proposed listing rule—although this is a relatively small number of species (19–34). Despite the smaller number of species, we estimate meaningful and precise higher sale prices inside CHs following the proposed listing rule—when there is no knowledge regarding the yet-to-be-announced CH border.

Turning to vacant lands, Panel (e) in Figure 8 shows the effects for designation by distance bins for 48 species and ≈110,000 residential vacant land transactions. We see no statistically significant effects on land values inside or outside of the listing boundary, except for a small and marginally significant appreciation 2km outside the habitat. The results for the "ever-conflict" subsample shown in Panel (f) are similar in showing no detectable effect.

Panels (g) and (h) show the same regressions but on the smaller sample of nonresidential vacant lands. Panel (g) shows a significant and sizable appreciation of lands just outside the boundary but no evidence of a drop in value for the small number of observations inside the boundary. The "ever-conflict" subsample mirrors these findings with a noisy estimate of some appreciation just outside the boundary. Given the extremely small sample sizes for the CH analysis of vacant lands, these results should be interpreted with caution.

The results we have covered thus far are those from our main specification and treatment onset assignment. In Section A.2 of the Online Appendix, we report results from varying the definition of treatment onsets, sample composition, finer temporal and cross-sectional fixed effects, clustering standard errors at higher levels of aggregation, changing the definitions of the subgroups of higher FWS consultations and ACE permits, and changing the outcome of interest to transaction count, as well as normalizing sale price by area. Next, we examine key dimensions of potential heterogeneity.

## 7.4 Heterogeneity by Species & Timing of Treatment

Although our results suggest that the average long-run effect of the ESA on property values is small for species listings and modest for CH designations, concluding the analysis with this finding would fail to highlight two significant sources of heterogeneity that appear to be meaningful in addition to the subgroup analysis shown in Figure 7, which determine the impacts experienced by landowners across the contiguous United States.

### 7.4.1 Species-Level Effects

The size of our dataset allows us to examine the effect on land values at the individual species level by running the regression from the previous sections but allowing the coefficient $\beta_1$ on the treatment variable in Equation 3 to vary by species. Figure 9 displays the distribution of estimated coefficients for this staggered DD estimation. We plot the distributions for these coefficients (unweighted, weighted by the number of transactions, weighted by the inverse of the standard error, and weighted by the mean of the preproposal price). The left column of graphs displays the results for SHs; the right column displays the distributions for CH designations. Each row reports the distribution of coefficients for a different land type. The takeaway is simple—the heterogeneity in species-level effects is massive.[11]

For SHs and residential properties, we observe larger densities for negative price effects inside the protected areas after the proposed listing. This finding is especially striking when we weight the coefficients by the number of total transactions—highlighting that more negative effects are concentrated in land markets with higher transaction volume. These distributions capture the overall average negative treatment effect we observe in the spatial DD (see Figure 6, Panels c and e); however, that is masking this important heterogeneity by species and land market. From the results we report in Figure 9, Panel (a), we learn that the negative effect we estimate in the spatial DD is attenuated by the few cases where the

[11] We further examine heterogeneity by species in Tables A9–A12, where we fail to find meaningful correlations between the species-specific effects and a variety of species-level characteristics.

effect is positive.

For residential properties in CHs, we also observe more density for negative coefficients. This pattern holds across the different weighting alternatives. More importantly, the density curves are skewed to the left, highlighting that in some combinations of species and land markets, the effects are negative and of greater magnitude than where they are positive. The price effects for residential properties, in both species and CHs, are largely centered around 0. An analysis that aggregates all of these species-specific effects will fail to capture the larger density of the negative effects, especially those that point to nontrivial reductions in land values.

The wide range of effects we estimate here highlights the difficulties in making blanket statements regarding the impacts of ESA protections on land markers. Critics of the ESA often point to cases where conservation led to considerable losses in land values. It is likely that the coefficients in the negative tails of these distributions are those that get the attention of policy circles and are raised as potential cautionary tales. However, those left-tail cases are not representative of the entire span of effects experienced by different land markets.

For vacant lands, those that we classify as residential and nonresidential, we observe distributions that display more heterogeneity, though symmetric and centered at 0. However, these distributions are also more compressed, with substantial density for effects, positive and negative, farther away from the center than for residential properties. Although we observe this pattern of wider dispersion for both species and CHs, we are more limited with CHs and vacant lands because of the smaller number of species, land markers, and transactions. Two facts contribute to the lower sample size of vacant lands around CH border. First, not all species receive a designation. Second, vacant land transactions are sparser relative to residential property transactions.

#### 7.4.2 ESA Treatment Timing

The process through which ESA listing and designation decisions take place means that no clear event qualifies as the single onset of treatment. A listing has both proposed and final rules, and a designation can have its own set of proposed and final rules, which do not necessarily overlap with the listing rules. In addition, petitioning or filing an action-forcing lawsuit against the FWS can also provide meaningful information to land markets. This yields potentially five or six events of interest.

Each event changes landowner expectations regarding the probability of binding land-use constraints that arise from ESA protections. In the results discussed earlier, we focused on the proposed listing or designation as the event of interest and aggregated the different events in the posttreatment period. For example, for SHs, we did not attempt to disentangle the effect after the final listing of the species from the one between the proposed and final listing. Aggregating the different treatment events can lead to estimating an average null effect if those distinct events have effects that offset each other.

The progression and evolution of ESA events provide more information about the certainty of listing and the degree to which land-use protections will be binding. As a result, the timing of a land transaction relative to the timing of each distinct ESA event is another meaningful source of heterogeneity. We estimate how sale prices change as the ESA events progress over time—effectively estimating a coefficient for each block in Figure 4, using the specification in Equation (3). Our goal is to estimate how sale prices change inside versus outside, as the ESA treatment stages advance from some common knowledge about potential ESA protection, to the realization of statutory protections.[12]

The results from this empirical exercise highlight the challenge of making a statement about the average treatment effect of land-use restrictions that follow ESA listings and designations. We discuss these results in greater detail in the Online Appendix, Section A.3. As a high-level summary of these findings, we do observe lower sale prices inside

[12] We focus our estimation on the 3km inside the protected area and up to 6km outside.

protected areas after the proposed listing rule. However, those effects are often temporary and either partially or fully offset after the final listing or designation. When we combine the estimates for the effects after the proposed and final listings, the net results are often small effect sizes for which we cannot reject the null hypothesis of a zero effect at the 5 percent significance level. Another pattern that broadly holds is that properties outside the protected area appreciate after the final listing. Finally, we estimate that sale prices are lower after a lawsuit or petition event; however, we have transaction data for only a small number of species that have a lawsuit or petition (e.g., 28 species relative to 195 for SHs).

# 8 The Impacts of the ESA on Construction Activity

Restrictions on land use that follow ESA protections might not be fully captured in the price of lands and properties—as the total effect on prices is ex-ante ambiguous (see Section 4 for more details). Another avenue through which the act might impose additional costs is procedural delays in developing land parcels. Such delays and uncertainty about their magnitude and cost might have effects on land markets not immediately captured in prices. Following the listing and designation decisions, private land developers might experience longer wait times for permits. Permits are required from several local and federal entities, and each must consult with the FWS to verify the approval does not present a risk to the survival of a listed species (referred to as the "federal nexus," see Section 3 for more details). Land developers can expect delays to increase with the number of protected species that are considered to have a habitat in the proposed project area.

In this section, we present several descriptive empirical facts that examine whether ESA protections have an effect on the permitting process for construction activity. We fail to find that more area under protection is correlated with meaningfully lower construction activity, yet we do observe longer delays—especially for larger projects. We begin with reviewing overall construction permits, study permits issued by the ACE, examine the time from application to approval of construction permits, and summarize the time it takes to complete an HCP (which is required in some cases and done preemptively in others to avoid costly delays and restrictions).

Instead of the timing of treatment and distance to the border of the protected area, we focus on the amount of local land area where development could be restricted by the ESA. We construct a county-year level dataset on the amount of land under the purview of the ESA. Explicitly, we calculate the sum of the number of acres that are part of SHs or CHs. We either count the unique acres in each category or allow the double-counting of overlapping acres. Counting the total, not necessarily unique, acres allows us to capture potential increases in treatment intensity if multiple protected species that occupy the same habitat increase the probability of action by the FWS that could delay development. To account for how acres in more densely populated areas might be more affected, we use population weights when constructing the different acre totals (see the Online Data Appendix for more details on the construction of these data).

## 8.1 Evaluating Changes to Housing Supply Using Construction Permits

Aggregate construction activity might decline if more species become protected in a locality and those restrictions prove binding. We use data on total construction permits and find no relationship between county acres that are habitats of protected species and total permits issued. Figure 10 shows binned scatter plots for the logged number of construction permits, level of permits, or permits per capita (per 1,000 people), versus the total (not necessarily unique) acres of SHs. We summarize the data as either the permits versus acres in a given year, by bin, or the first differences of permits versus the first differences of acres.

Across the three ways we use the number of permits data (logs, levels, or rates), we fail to detect a sharp and meaningful gradient where potential higher ESA treatment intensity is correlated with lower construction activity. Most of the distribution of the permits versus acres in a given year is a flat slope. If anything, construction permit numbers increase near the top end of total SH acres (see Online Appendix, Figure A31 for a comparison using unique acres). An alternative way to examine this relationship is to look at the changes, in first differences, in permits and protected acres. We summarize those first differences in binscatters; in these figures, we observe negative slopes, yet their magnitude suggests modest impacts. For logged permits and permit rate, the magnitude of change is bounded by less than 0.1 standard deviation of the logged permits, or permit rate. In levels, the slope is steeper, reflecting a change of about 0.3 standard deviations.

Land markets might respond to intensifying protections with a delay, making it harder to observe an effect on construction activity in the first differences approach. To account for responses that occur over longer time horizons, we repeat the first differences approach for second up to fifth differences in the Online Appendix, Figure A32. When we examine fourth and fifth differences (permits and protected acres today relative to four or five years ago), we observe slopes that are four to five times larger than in the first differences case—as high as 0.5 standard deviations. However, interpretation becomes more challenging as the measurement spans longer time horizons. At best, these results provide suggestive evidence that over the time scale of years, growing ESA protections can suppress, on average, construction activity by nontrivial magnitudes.

## 8.2 Evidence for Potential Delays Using ACE Permits

The ACE, like all federal agencies, is required to consult with the FWS before it issues development permits. The ACE makes it clear that no construction work may commence "until a permit has been issued by the Corps that the requirements of the ESA have been satisfied."[13] For example, in 2021, the ACE revoked a permit for housing developments in Trestle Creek and Lake Pend Oreille, Idaho. It was issued in 2009, but after a lawsuit, the

[13] See the ESA section on the ACE website for more details: https://www.nww.usace.army.mil/Business-With-Us/Regulatory-Division/Permit-Processes/ESA-Endangered-Species-Act/. Accessed: August 5th, 2023.

ACE determined that canceling it was warranted because it jeopardized the habitats of the bull trout (a fish species listed as threatened since 1999). The developers could still apply for a new permit, but that would require a full environmental review, an environmental impact statement, public interest review with a period open for public comments, and a full consultation with the FWS.[14]

A landowner who applies for a permit from the ACE faces uncertainty about the type of permit they will obtain, if at all, and how long it will take. ACE's first decision is whether an application for a permit falls under an exemption. Starting in 2002, the ACE has issued fewer permits, as more applications have been granted exemption under different categories.[15] If the application is not found to be exempt or denied, a permit can be issued as either a Letter of Permission or Standard Permit (see the Online Data Appendix for more details on the permit types). The specific permit action is an important feature of how ACE permitting might change as a result of additional ESA protections. In Figure D5, we summarize the secular trends in the total number of permits, by decision outcome, and by permit type.

Binding ESA protections could lead to higher permit denial rates and a shift toward longer review times and approvals with added stipulations. Standard permits result in longer, well above 120 days, approval processes relative to a letter of permission. In addition, permits issued with special conditions might involve costly compliance costs.

We modify the method of counting habitat acres that we used for total construction permits in two important ways. First, we allow all species, not just the not solely aquatic species, to contribute. Second, we narrow the spatial extent in each county in which we

[14] For more details, see: https://www.khq.com/news/idaho_news/army-corps-stopping-housing-development-on-lake-pend-oreille/article_d283429c-3aba-11ed-8dee-e79e83376d1c.html. Accessed: August 5th, 2023.

[15] The ACE uses a set of guidelines, the nationwide permits, to offer exemptions from review in cases where the development is expected to have a "minimal impact the nation's aquatic environment." The ACE offers a summary that helps assess which activities or projects fall under the exemption or not. See https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/Obtain-a-Permit/ for more details (Accessed June 13, 2024). As part of the 2002 nationwide guidelines, which updated the 1996 nationwide permits guidelines, the ACE made modifications to nine existing permit types and to six general conditions, while adding one new general condition (US Army Corps of Engineers 2002).

count the acres to a 10km buffer around lakes and rivers. These two changes mean that we are focusing on species whose habitats are in, or near, aquatic features, which might be relevant to the ACE when granting a permit. In other words, we construct a measure of protected acres that are more connected to the decision making process by only counting acres that are near water bodies. To distinguish this count of acres from the previous one, we refer to this as "near-water habitats."

The composition of permits issued by the ACE leans more toward private landowners and developers experiencing greater regulatory stringency due to higher levels of protected acres under the ESA. In Figure 11, we plot binned values for the percent of permits issued with special conditions, the percent of permits issued as standard, or the share of denied permits as a function of total species acres near-water habitats, in log points. All three panels suggest a convex relationship between listed acres and the share of permits that are likely to reflect higher costs and longer delays for developers. Online Appendix Figure A33 shows similar changes in the composition of permit type changes relative to unique, instead of total, acres. In addition, in Figure A34, we observe that the total counts of permit applications and permit denials are increasing with higher protected acres, yet the latter is increasing relatively more, leading to the observed higher share of denied permits.

## 8.3 Evidence for Potential Delays Using Individual Construction Permit Approvals

We examine delays in construction permits by using data on the time between permit application and approval dates. This provides the most direct measure of potential delay; however, we observe these permits only for a subsample of land markets and years. Our analysis relies on data we purchased from BuildZoom on new construction building permits (see Section 5 for more details). Each permit is geocoded and has a unique identifier, allowing us to calculate the time between its application and approval. Using the location and timing information for each permit, we classify it as inside or outside of the protected area and label it as filed before or after the proposed listing or designation rule.

We observe what we can interpret as weak, at most, evidence that would support longer approval time for new construction permits. In Figure 12, we plot similar regressions output as in Figure 6, only instead of using the logged sale price as the outcome, we use the number of days from application to issuance. In the two years after a proposed listing rule, we observe an increase of about 25 days, on average, inside the protected area (Panels a and c). However, those increases are noisily estimated and vanish once we extend the sample to five years after the proposed listing rule (panel e). CHs have no meaningful effect in the two years after the proposed designation rule (Panels b and d). In contrast, we do observe a spike in approval time of about 100 days inside the CH, but only when extending the sample to five years after the proposed designation (Panel f). As in the previous results for inside the CHs, these results reflect but a fraction, approximately 2 percent, of the total permits in the sample. Even when we examine the distribution of approval time, we fail to find a clear pattern of longer delays inside after protections are proposed (Figure A30) (as demonstrated by the similarity in the distributions marked by the red dashed and solid lines).

### 8.4 Evidence for Potential Delays Using Habitat Conservation Plans

Our analysis of construction permits as measured by the Census, ACE, and data from BuildZoom did not reveal reduced building activity, reflecting a null, on average. However, the composition of ACE permits suggested longer delays, which was sometimes supported by BuildZoom data. We test for other regulatory mechanisms through which the ESA might introduce compliance costs that require additional planning, which could delay projects.

To more accurately evaluate how the ESA might delay construction projects, we use data on Habitat Conservation Plans (HCPs). When a landowner seeks to develop land that is considered a habitat of a listed species, their project is likely to go under review by the FWS (see Section 3 regarding the federal nexus). The FWS might determine that the developer needs to obtain an incidental taking permit, which establishes mandatory steps for the landowner to reduce the damage that might occur to the species' habitat during development. The process to obtain such a permit requires an HCP.

In other cases, landowners might preemptively develop an HCP even before a species is listed. If their HCP is approved by the FWS, then they receive a "no surprises assurance." This means that if the species does become listed during development, they will not need to create a new plan or undertake any precautionary steps that were not outlined in the approved HCP. Landowners have referred to HCPs as "burdensome" (Murray 1997) and costly, especially for small landowners (Paulich 2010) and blamed the FWS for using negotiations and delays to reduce the approved level of development (Sheldon 1997). We use data on the time from the first initiated date of an HCP to its final approval from 1990 to 2019 and summarize the data as simple histograms in Figure 13.

On average, an HCP takes about five years. Although this is a long period, this simple mean hides important heterogeneity. Many HCPs take more than twice that time. In Figure 13a, we show that the distribution in years between HCPs for all land uses and construction projects is similar. Focusing on the latter, we find that projects that cover larger areas, request a longer duration for their incidental taking permit, and were initiated before 2001 take considerably longer (Panels b–d). For example, projects above the median level of land covered or permit duration rarely get approved under four years and average two years more for planning periods (Panels b and c). We document small, if any, differences in approval periods between animals and plants, aquatic and nonaquatic species, species listed as endangered relative to threatened, or species that ever receive a CH designation (Panels e–h).

Evidence on the compliance costs involved with an HCP is scarce. A notable example is a detailed review by Surrey et al. (2022) of 43 plans. They calculate that ESA compliance costs reflect at least 77 and up to 97 percent of total projected HCP costs. Their review summarizes that the median small-scale plan has costs of about $4 million, and a large-scale plan has a median cost of $100 million. The largest cost item, by an order of magnitude, is restoring and/or purchasing of habitat to mitigate damages from the proposed development. Construction sectors have considerable heterogeneity; the real-estate development sector has by far the highest median cost at close to $180 million—larger by one or two orders of magnitude. In short, HCPs present a substantial challenge to land developers in terms of both the time it take to compile and approve them and the compliance costs.

# 9 Conclusions

We compile a new national data set and use it to evaluate how land markets respond to protections on species under the ESA. Our main findings recover how listing and designation decisions affect property sale prices. On average, the listing of species under the act results in small noisily estimated reductions in sale price inside the habitat range of the species, while designations of critical habitats mostly lead to price increases right outside the protected area—in large part because the border is drawn right where the volume of transactions was already low. We find considerable heterogeneity in these average effects across sub-groups in which the ESA restrictions might be more binding, as well as dispersed distributions of species-specific effects. These findings advance our understanding of the impacts of the ESA over the past decades across the contiguous US. The fact that we observe several cases where prices respond meaningfully to ESA protections validates the importance of papers that study individual species listings and designations, however, those estimates need to be interpreted against the more muted distribution of ESA treatment effects.

We supplement the sale price analysis by descriptively summarizing how construction permit activity correlates with more land under ESA statutory protection, and find suggestive evidence that while the amount of construction is not changing, the ESA might be delaying construction activity. These findings corroborate more anecdotal sentiments expressed in policy circles and popular writings about the ESA. Further research is needed on how land developers respond and adjust to ESA-based restrictions on land use. Further work is also needed on how the ESA is implemented and enforced in different locations, and how ESA implementation changes over time, is an important avenue for future research in economics and policy/law. We also note that for a proper benefit-cost analysis, one requires credible estimates of the benefits of species protection. This is a challenging, but most important area of applied research going forward.

# References


Alacevich, Caterina, Petyo Bonev, and Magnus Söderberg. 2021. "Pro-Environmental Interventions and Behavioral Spillovers: Evidence from Organic Waste Sorting in Sweden." *Journal of Environmental Economics and Management* 108:102470.

Albouy, David, Peter Christensen, and Ignacio Sarmiento-Barbieri. 2020. "Unlocking Amenities: Estimating Public Good Complementarity." *Journal of Public Economics* 182:104110.

Ando, Amy W., and Christian Langpap. 2018. "The Economics of Species Conservation." *Annual Review of Resource Economics* 10(1):445–67.

Auffhammer, Maximilian, 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.

Auffhammer, Maximilian, and Ryan Kellogg. 2011. "Clearing the Air? The Effects of Gasoline Content Regulation on Air Quality." *The American Economic Review* 101(6):2687–722.

Autor, David H. 2003. "Outsourcing at Will: The Contribution of Unjust Dismissal Doctrine to the Growth of Employment Outsourcing." *Journal of Labor Economics* 21(1):1–42.

Bahrami, Golnaz, Matthew Gustafson, and Eva Steiner. 2024. "The Biodiversity Protection Discount." *Working Paper.*

Bajari, Patrick, and C. Lanier Benkard. 2005. "Demand Estimation with Heterogeneous Consumers and Unobserved Product Characteristics: A Hedonic Approach." *Journal of Political Economy* 113(6):1239–76.

Barnosky, Anthony D., Nicholas Matzke, Susumu Tomiya, Guinevere O.U. Wogan, Brian Swartz, Tiago B. Quental, Charles Marshall, et al. 2011. "Has the Earth's Sixth Mass Eextinction Already Arrived?" *Nature* 471(7336):51–7.

Bento, Antonio, Matthew Freedman, and Corey Lang. 2015. "Who Benefits from Environmental Regulation? Evidence from the Clean Air Act Amendments." *Review of Economics and Statistics* 97(3):610–22.

Borusyak, Kirill, Xavier Jaravel, and Jann Spiess. 2024. "Revisiting Event Study Designs: Robust and Efficient Estimation." *Review of Economic Studies* 91(6):3253–85.

Bošković, Branko, and Linda Nøstbakken. 2017. "The Cost of Endangered Species Protection: Evidence from Auctions for Natural Resources." *Journal of Environmental Economics and Management* 81:174–92.

Brown, Gardner M., and Jason F. Shogren. 1998. "Economics of the Endangered Species Act." *Journal of Economic Perspectives* 12(3):3–20.

Callaway, Brantly, and Pedro HC Sant'Anna. 2021. "Difference-in-Differences with Multiple Time Periods." *Journal of Econometrics* 225(2):200–30.

Ceballos, Gerardo, Paul R. Ehrlich, Anthony D. Barnosky, Andrés García, Robert M. Pringle, and Todd M. Palmer. 2015. "Accelerated Modern Human–Induced Species Losses: Entering the Sixth Mass Extinction." *Science Advances* 1(5):1–5.

Chay, Kenneth Y., and Michael Greenstone. 2005. "Does Air Quality Matter? Evidence from the Housing Market." *Journal of Political Economy* 113(2):376–424.

Currie, Janet, and Reed Walker. 2011. "Traffic Congestion and Infant Health: Evidence from E-ZPass." *American Economic Journal: Applied Economics* 3(1):65–90.

———. 2019. "What Do Economists Have to Say about the Clean Air Act 50 Years after the Establishment of the Environmental Protection Agency?" *Journal of Economic Perspectives* 33(4):3–26.

Davis, Lucas W. 2004. "The Effect of Health Risk on Housing Values: Evidence from a Cancer Cluster." *American Economic Review* 94(5):1693–704.

———. 2011. "The Effect of Power Plants on Local Housing Values and Rents." *Review of Economics and Statistics* 93(4):1391–402.

De Chaisemartin, Clément, and Xavier D'Haultfœuille. 2020a. "Difference-in-Differences Estimators of Intertemporal Treatment Effects." *Available at SSRN 3731856.*

De Chaisemartin, Clément, and Xavier d'Haultfoeuille. 2020b. "Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects." *American Economic Review* 110(9):2964–96.

De Janvry, Alain, Kyle Emerick, Marco Gonzalez-Navarro, and Elisabeth Sadoulet. 2015. "Delinking Land Rights from Land Use: Certification and Migration in Mexico." *American Economic Review* 105(10):3125–49.

Diamond, Rebecca, and Tim McQuade. 2019. "Who Wants Affordable Housing in Their Backyard? An Equilibrium Analysis of Low-Income Property Development." *Journal of Political Economy* 127(3):1063–117.

Dirzo, Rodolfo, Hillary S. Young, Mauro Galetti, Gerardo Ceballos, Nick J.B. Isaac, and Ben Collen. 2014. "Defaunation in the Anthropocene." *Science* 345(6195):401–06.

Drewnowski, Adam, Anju Aggarwal, Colin D. Rehm, Hannah Cohen-Cline, Philip M. Hurvitz, and Anne V. Moudon. 2014. "Environments Perceived as Obesogenic Have Lower Residential Property Values." *American Journal of Preventive Medicine* 47(3):260–74.

Endangered Species Act of 1973, Pub. L. No. 93-205, 87. 1973. 884–903.

Ferris, Ann E., and Eyal G. Frank. 2021. "Labor Market Impacts of Land Protection: The Northern Spotted Owl." *Journal of Environmental Economics and Management* 109:102480.

Fowlie, Meredith, Michael Greenstone, and Catherine Wolfram. 2018. "Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program." *The Quarterly Journal of Economics* 133(3):1597–644.

Frank, Eyal. 2024. "The Economic Impacts of Ecosystem Disruptions: Costs From Substituting Biological Pest Control." *Science* 385(6713):eadg0344.

Frank, Eyal, and Anant Sudarshan. 2024. "The Social Costs of Keystone Species Collapse: Evidence From The Decline of Vultures in India." *American Economic Review* 114(10):3007–40.

Glaeser, Edward L., and Joseph Gyourko. 2003. "The Impact of Building Restrictions on Housing Affordability." *Economic Policy Review* 9(2).

Glaeser, Edward L., Joseph Gyourko, and Raven E. Saks. 2005. "Why Have Housing Prices Gone Up?" *American Economic Review: Papers & Proceedings* 95(2):329–33.

Goble, Dale. 2005. *The Endangered Species Act at Thirty: Vol. 1.* Island Press.

Goodman-Bacon, Andrew. 2021. "Difference-in-Differences with Variation in Treatment Timing." *Journal of Econometrics* 225(2):254–77.

Greenstone, Michael, and Justin Gallagher. 2008. "Does Hazardous Waste Matter? Evidence from the Housing Market and the Superfund Program." *The Quarterly Journal of Economics* 123(3):951–1003.

Greenstone, Michael, and Ted Gayer. 2009. "Quasi-Experimental and Experimental Approaches to Environmental Economics." *Journal of Environmental Economics and Management* 57(1):21–44.

Grupp, Tristan Earle, Prakash Mishra, Mathias Reynaert, and Arthur A. van Benthem. 2024. "An Evaluation of Protected Area Policies in the European Union." *Working Paper.*

Hanley, Nick, and Charles Perrings. 2019. "The Economic Value of Biodiversity." *Annual Review of Resource Economics* 11(1):355–75.

Houck, Oliver A. 1993. "The Endangered Species Act and its Implementation by the US Departments of Interior and Commerce." *University of Colorado Law Review* 64:277.

IPBES. 2019. *IPBES, 2019. Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.* Edited by S. Díaz, J. Settele, E S Brondízio, H.T. Ngo, M. Guèze, J. Agard, A. Arneth, et al. IPBES secretariat, Bonn, Germany.

Ito, Koichiro, and James Sallee. 2018. "The Economics of Attribute-Based Regulation: Theory and Evidence from Fuel-Economy Standards." *Review of Economics and Statistics* 100(2):319–36.

Keiser, David A. 2019. "The Missing Benefits of Clean Water and the Role of Mismeasured Pollution." *Journal of the Association of Environmental and Resource Economists* 6 (4): 669–707.

Kiel, Katherine, and Jeffrey Zabel. 2001. "Estimating the Economic Benefits of Cleaning up Superfund Sites: The Case of Woburn, Massachusetts." *The Journal of Real Estate Finance and Economics* 22(2):163–84.

Kuminoff, Nicolai V., Christopher F. Parmeter, and Jaren C. Pope. 2010. "Which Hedonic Models Can We Trust to Recover the Marginal Willingness to Pay for Environmental Amenities?" *Journal of Environmental Economics and Management* 60(3):145–60.

Kuminoff, Nicolai V., and Jaren C. Pope. 2014. "Do "Capitalization Effects" for Public Goods Reveal the Public's Willingness to Pay?" *International Economic Review* 55(4):1227–50.

Kuminoff, Nicolai V., V. Kerry Smith, and Christopher Timmins. 2013. "The New Economics of Equilibrium Sorting and Policy Evaluation Using Housing Markets." *Journal of Economic Literature* 51(4):1007–62.

Langpap, Christian. 2022. "Interest Groups, Litigation, and Agency Decisions: Evidence from the Endangered Species Act." *Journal of the Association of Environmental and Resource Economists* 9(1):1–26.

Linden, Leigh, and Jonah E. Rockoff. 2008. "Estimates of the Impact of Crime Risk on Property Values from Megan's Laws." *American Economic Review* 98(3):1103–27.

List, John A., Michael Margolis, and Daniel E. Osgood. 2006. "Is the Endangered Species Act Endangering Species?" *NBER Working Paper No. 12777.*

Lueck, Dean, and Jeffrey A. Michael. 2003. "Preemptive Habitat Destruction Under the Endangered Species Act." *The Journal of Law & Economics* 46(1):27–60.

Mamun, Saleh, Erik Nelson, and Christoph Nolte. 2023. "Estimating the Impact of Critical-Habitat Designation on the Values of Developed and Undeveloped Parcels." *Land Economics* 100(1):148–75.

Mann, Charles C., and Mark L. Plummer. 1995. *Noah's Choice: The Future of Endangered Species.* Alfred A. Knopf, New York.

McConnell, Virginia, and Margaret Walls. 2005. "The Value of Open Space: Evidence from Studies of Nonmarket Benefits." *Lincoln Institute of Land Policy Working Paper.*

Melstrom, Richard T. 2017. “Where to Drill? The Petroleum Industry’s Response to an Endangered Species Listing.” *Energy Economics* 66:320–27.

Metrick, Andrew, and Martin L. Weitzman. 1998. “Conflicts and Choices in Biodiversity Preservation.” *Journal of Economic Perspectives* 12(3):21–34.

Muehlenbachs, Lucija, Elisheba Spiller, and Christopher Timmins. 2015. “The Housing Market Impacts of Shale Gas Development.” *American Economic Review* 105(12):3633–59.

Murray, Tobie. 1997. “An Endangered Habitat Act to Help Landowners Protect Wildlife.” *Ecology Law Quarterly* 24(4):689–93.

Owen, Dave. 2012. “Critical Habitat and the Challenge of Regulating Small Harms.” *Florida Law Review* 64:141.

Paulich, Nathan. 2010. *Increasing Private Conservation Through Incentive Mechanisms.* https://www-cdn.law.stanford.edu/wp-content/uploads/2018/05/paulich.pdf. Accessed: July 18, 2021.

Pimm, S.L., C.N. Jenkins, R. Abell, T.M. Brooks, J.L. Gittleman, L.N. Joppa, P.H. Raven, C.M. Roberts, and J.O. Sexton. 2014. “The Biodiversity of Species and their Rates of Extinction, Distribution, and Protection.” *Science* 344(6187):1246752.

Powell, Frona M. 1995. “Defining Harm Under the Endangered Species Act: Implications of Babbitt v. Sweet Home.” *American Business Law Journal* 33(1):[i]–152.

Quigley, John M., and Steven Raphael. 2005. “Regulation and the High Cost of Housing in California.” *American Economic Review: Papers & Proceedings* 95(2):323–28.

Quigley, John M., and Larry A. Rosenthal. 2005. “The Effects of Land Use Regulation on the Price of Housing: What Do We Know? What Can We Learn?” *Cityscape* 8(1):69–137.

Reeves, Tyler, Bin Mei, Pete Bettinger, and Jacek Siry. 2018. “Review of the Effects of Conservation Easements on Surrounding Property Values.” *Journal of Forestry* 116(6):555–62.

Rosen, Sherwin. 1974. “Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition.” *Journal of Political Economy* 82(1):34–55.

Sheldon, Karin P. 1997. “Habitat Conservation Planning: Addressing the Achilles Heel of the Endangered Species Act.” *NYU Environmental Letters* 6:279.

Shogren, Jason F, John Tschirhart, Terry Anderson, Amy Whritenour Ando, Steven R. Beissinger, David Brookshire, Gardner M. Brown, et al. 1999. “Why Economics Matters for Endangered Species Protection.” *Conservation Biology* 13(6):1257–61.

Sims, Katharine R.E., Jonathan R. Thompson, Spencer R. Meyer, Christoph Nolte, and Joshua S. Plisinski. 2019. “Assessing the Local Economic Impacts of Land Protection.” *Conservation Biology: The Journal of the Society for Conservation Biology* 33(5):1035–44.

Stevenson, Betsey, and Justin Wolfers. 2006. "Bargaining in the Shadow of the Law: Divorce Laws and Family Distress." *Quarterly Journal of Economics* 121(1):267–88.

Sun, Liyang, and Sarah Abraham. 2020. "Estimating Dynamic Treatment Effects in Event Studies with Heterogeneous Treatment Effects." *Journal of Econometrics* 225(2):175–99.

Surrey, Katie C., Gwenllian Iacona, Becca Madsen, Christian Newman, and Leah R. Gerber. 2022. "Habitat Conservation Plans Provide Limited Insight into the Cost of Complying with the Endangered Species Act." *Conservation Science and Practice* 4(6).

Szabó, Andrea, and Gergely Ujhelyi. 2024. "National Parks and Economic Development." *Journal of Public Economics* 232:105073.

Turner, Matthew A., Andrew Haughwout, and Wilbert Van Der Klaauw. 2014. "Land Use Regulation and Welfare." *Econometrica* 82(4):1341–403.

US Army Corps of Engineers. 2002. *Issuance of Nationwide Permits; Notice,* 02-539.

Weitzman, Martin L. 1992. "On Diversity." *The Quarterly Journal of Economics* 107(2):363–405.

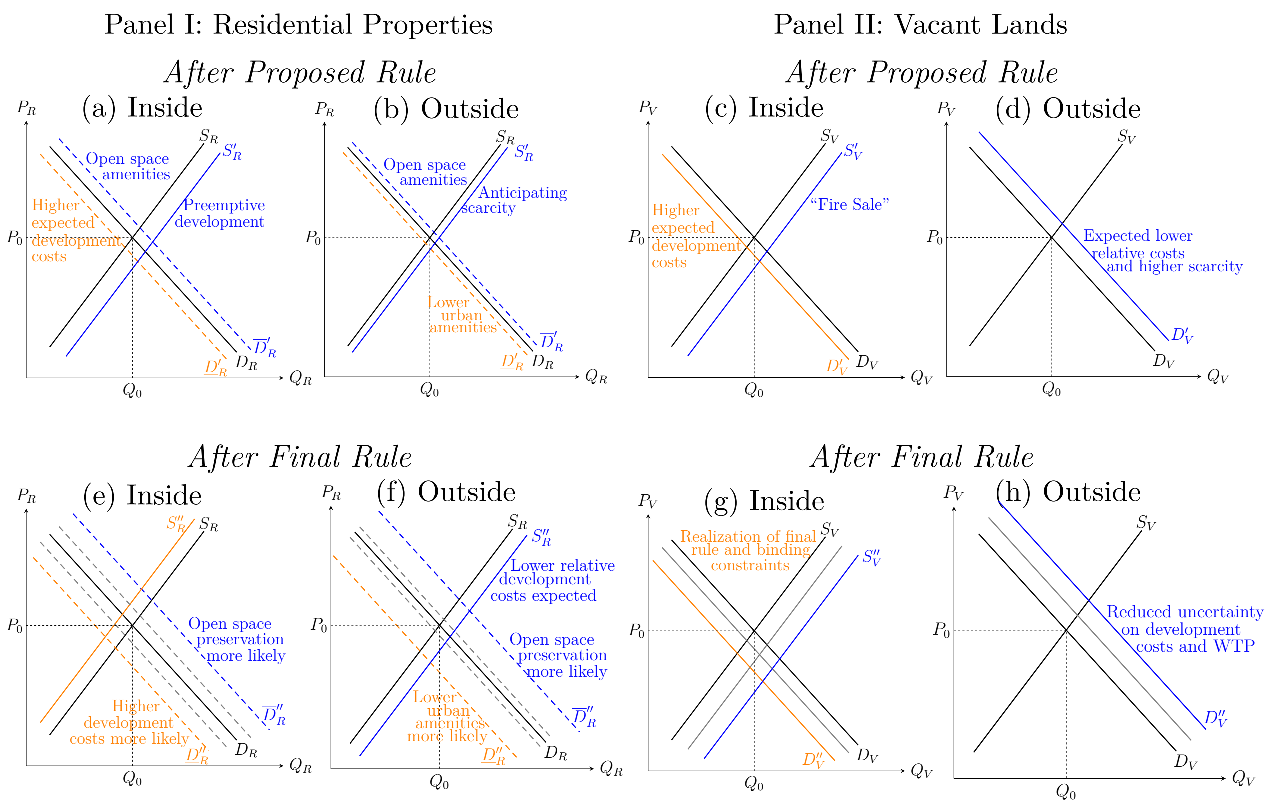
———. 1993. "What to Preserve? An Application of Diversity Theory to Crane Conservation." *The Quarterly Journal of Economics* 108(1):157–83.

World Wildlife Fund. 2020. *Living Planet Report 2020-Bending the Curve of Biodiversity Loss.* Edited by R.E.A. Almond, M. Grooten, and T. Peterson.

Zabel, Jeffrey E., and Robert W. Paterson. 2006. "The Effects of Critical Habitat Designation on Housing Supply: An Analysis of California Housing Construction Activity." *Journal of Regional Science* 46(1):67–95.

Zhang, Ling, Jiantao Zhou, Eddie C.M. Hui, and Haizhen Wen. 2019. "The Effects of a Shopping Mall on Hhousing Prices: A Case Study in Hangzhou." *International Journal of Strategic Property Management* 23(1):65–80.

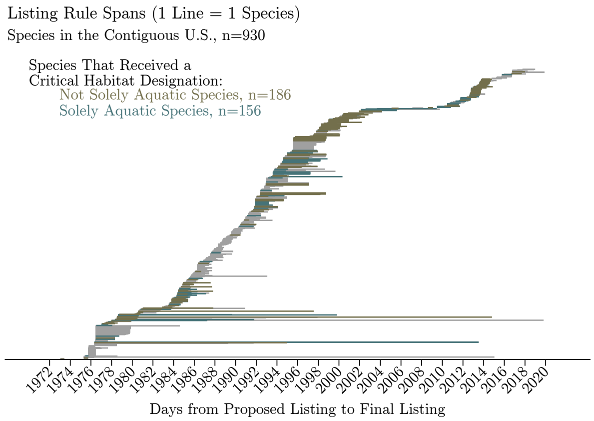
Figure 1: Theoretical Framework for Evaluating the Effects of Proposed and Final Rules



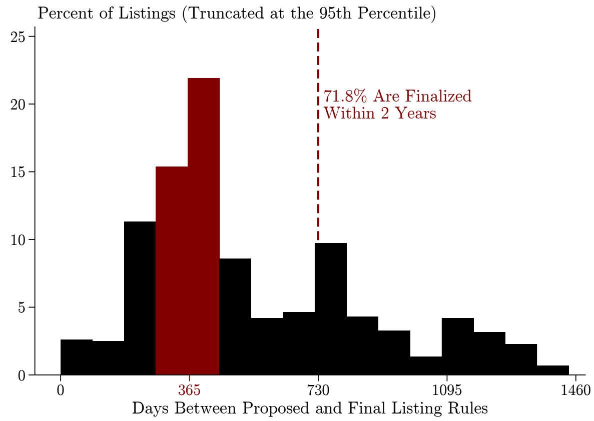

Notes: Each subpanel summarizes the theoretical predictions regarding the effects of statutory protections by the ESA. We consider how the effects could be different for either residential properties or vacant lands, after the proposed or final rule, inside or outside the protected area. In each subpanel, the solid black lines depict the equilibrium in the market prior to any proposed rule for ESA action. Solid blue lines denote a shift outward of either supply or demand, and yellow solid lines denote an inward shift. We use dashed line to denote ambiguity about the direction of the change (e.g., in Subpanel (a) where demand can either increase or decrease). To highlight the potential intensification of effects after the proposed rule, we use gray lines, dashed or solid, in the post-final-rule period to denote the location of the supply and demand curves in the post-proposed-period (e.g., in the change from (a) to (e), where demand curves shift more inward or outward, depending on the direction of the effect).

Figure 2: ESA Listings & Designations in the Contiguous United States

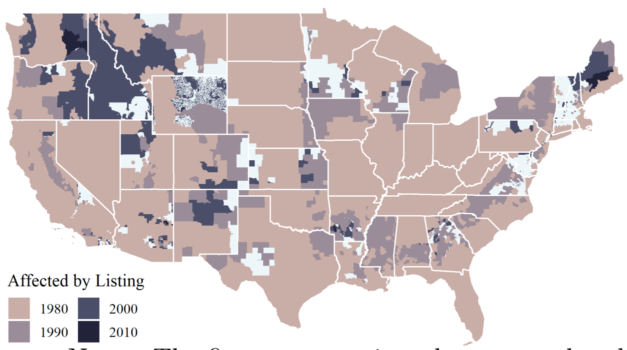
(a) Staggered Listings Under the ESA



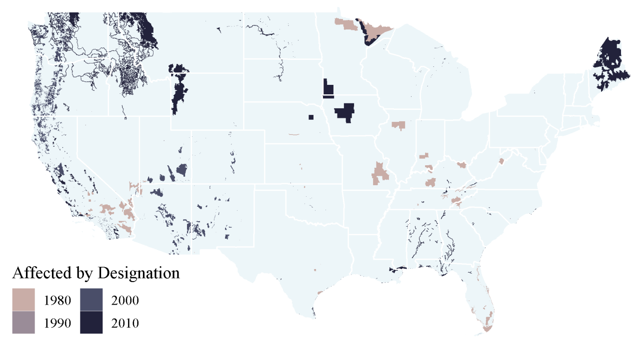

(b) Duration Until Listed




(c) Species Habitats Map



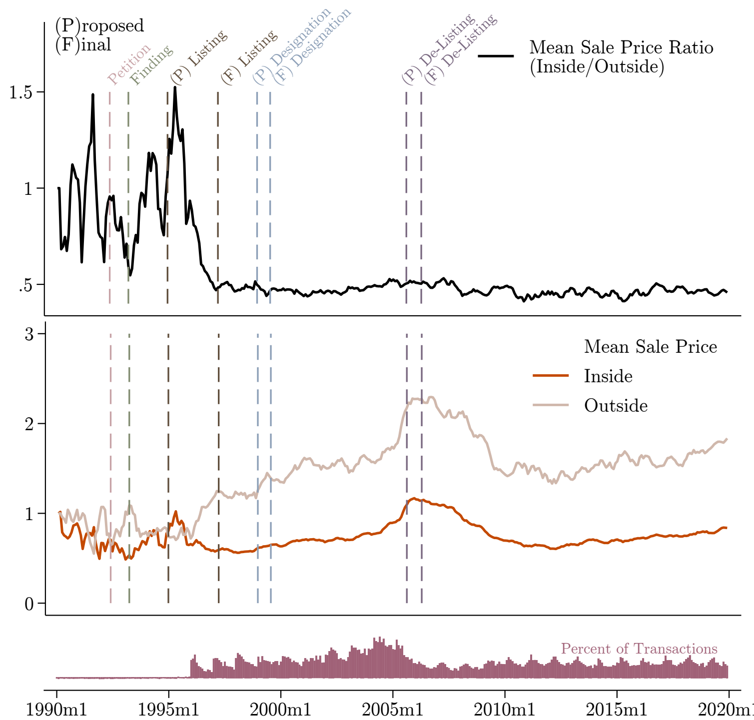

(d) Critical Habitats Map



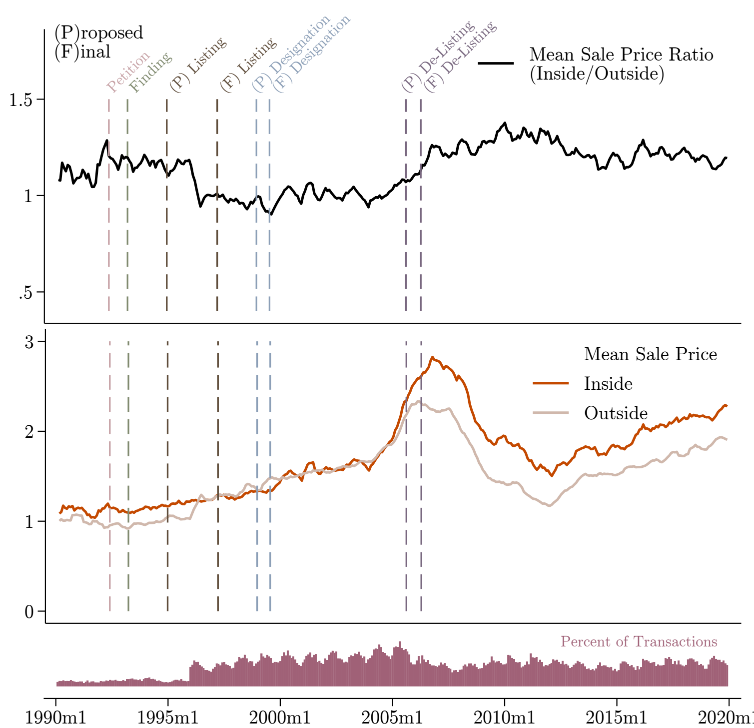

Notes: The figure summarizes the temporal and spatial variation in the listings and designations under the ESA. (a) The staggered phasing of species into protections, and the time in between their first proposed rule to list, and the final rule that confirms the listing, and awards statutory protections. Each line begins and ends on the date of the proposed and final rules for a specific species. (b) Summary of the duration between listing rules, truncated at the 95th percentile. (c) A map of habitat areas, by decade of their final rule, after excluding habitat areas that cover more than 99 percent of a state's land area. (d) Same as (c), only for critical habitats.

Figure 3: Temporal & Spatial Dimensions of the ESA: The Pygmy Owl Case Study

(a) Species Habitat



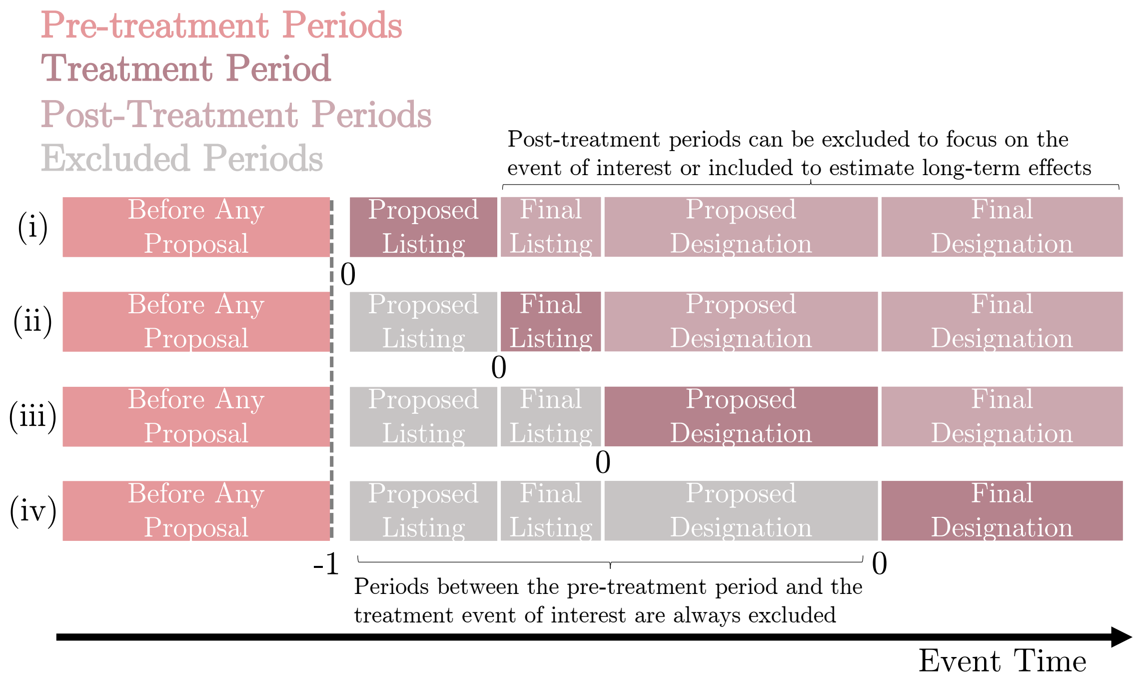

(b) Critical Habitat




Notes: Prices of residential properties in 2019 USD, normalized relative to January 1990. These prices are truncated at the 99th percentile, of which we take a 6-month moving average. Vertical dashed lines denote important ESA events related to the pygmy owl.

Figure 4: Schematic Research Design for Staggered Treatments

(a) Potential Comparisons Based on Fish and Wildlife Service Actions




(b) Example: Two Species, Case (ii)

| Calendar Time | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Species I | B | B | B | P | P | P | F | F | F |
| Species II | B | B | P | P | F | F | F | F | F |
| **Event Time** | -3 | -2 | -1 | | | | 0 | 1 | 2 |
| Species I | B | B | B | ~~P~~ | ~~P~~ | ~~P~~ | F | F | F |
| **Event Time** | -2 | -1 | | | 0 | 1 | 2 | 3 | 4 |
| Species II | B | B | ~~P~~ | ~~P~~ | F | F | F | F | F |

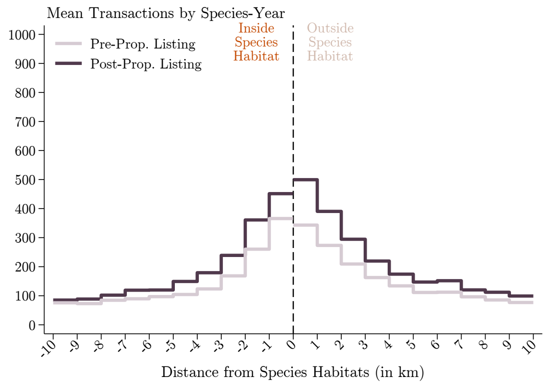
Notes: These figures summarize how we align ESA events in event time. First, we count the time up to the proposed listing of the species as negative event time. We treat these as the pretreatment periods. We then focus on a specific ESA event, such as a final listing or proposed designation, and count periods following the event as positive event time. Any periods between the first proposal to list or designate and the ESA event of interest are excluded them from the regression. Because species vary in their duration spent in each status, each event block is of a different length. See text for more details. Panel (a) shows the four possible comparisons we can make for each species based on the listing and designation events as determined by the Fish and Wildlife Service. Panel (b) shows an example of case (ii) from panel (a) for two species, where we focus on the effect of the final listing (F). We recenter before any proposal (B) and exclude the time periods where the species have a proposed listing status (P).

Figure 5: Number of Residential Property Transactions Around Habitat Borders

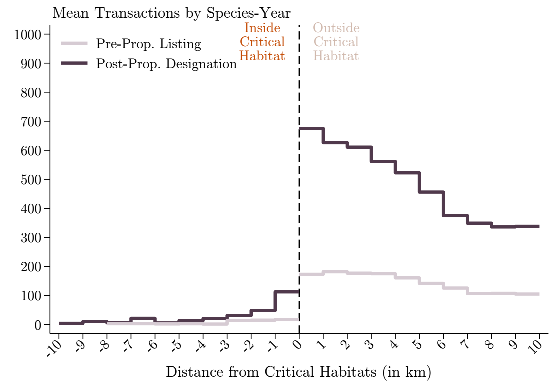
**Species Habitat** **Critical Habitat**

## Residential Properties

(a)

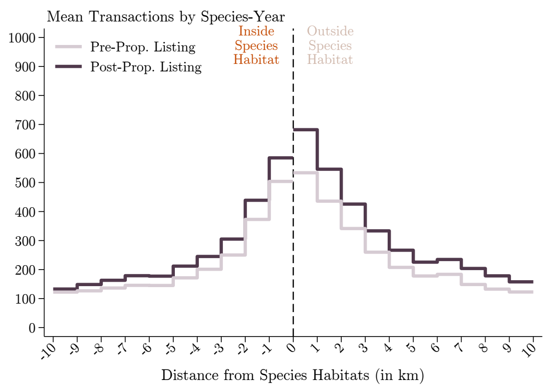



(b)

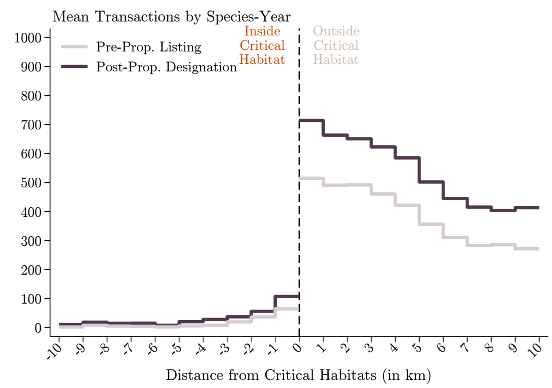



## Vacant Lands

(c)

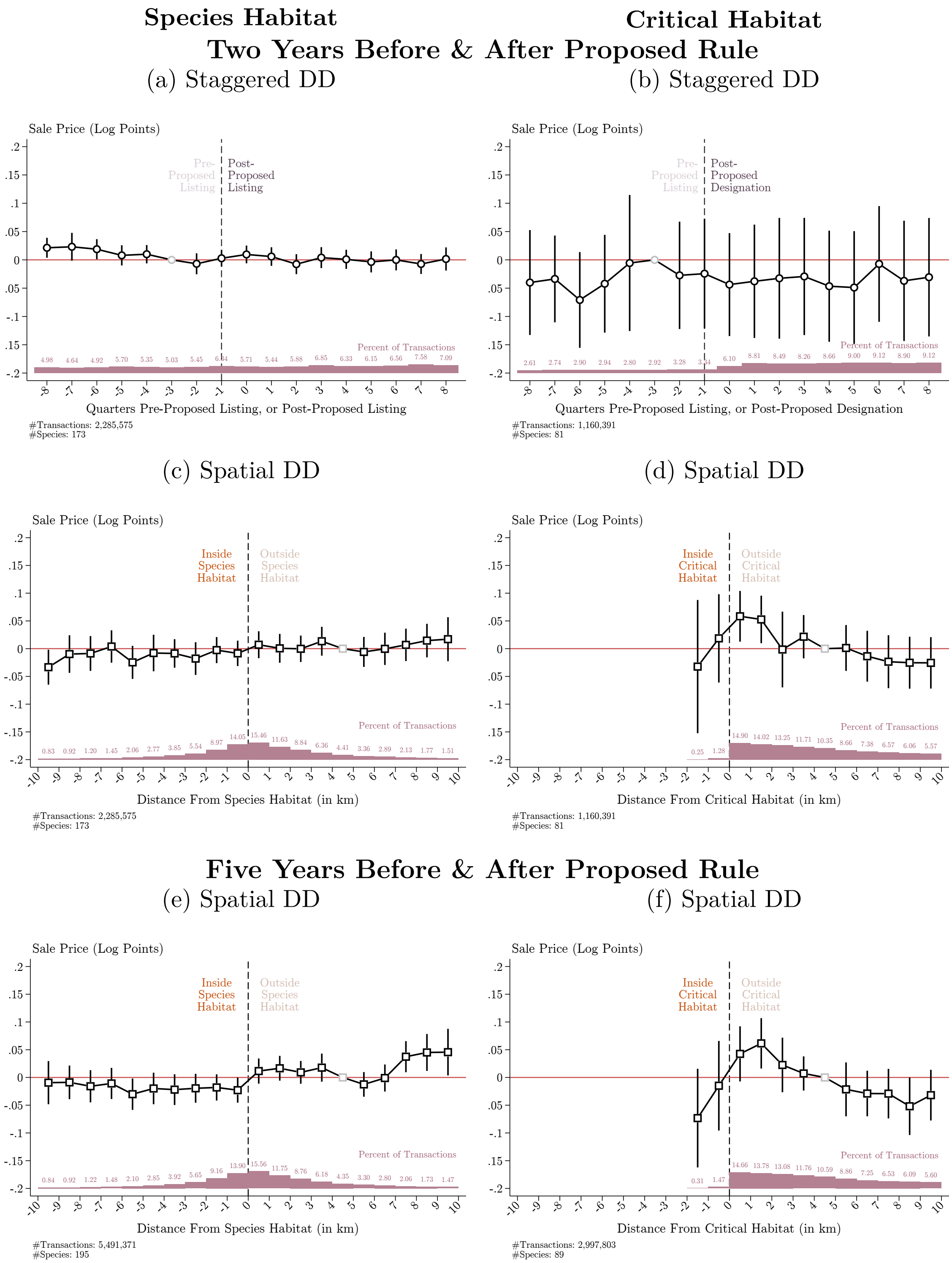



(d)



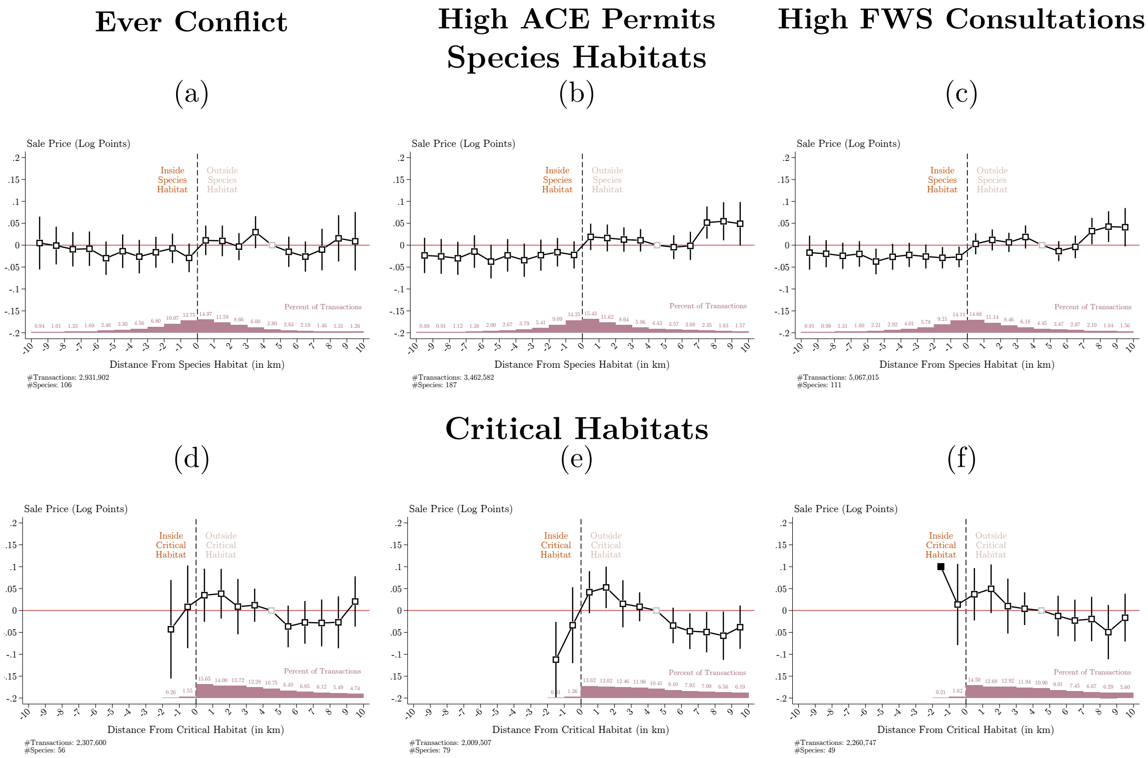

Notes: The figures summarize the number of transaction around the border of the species and critical habitats (CHs) before the listing proposal and after the final listing (SHs) or final designation (CHs). For residential properties and not solely aquatic species, we plot the transaction counts normalized by the number of species and the number of years of data available for before and after the proposed and final rules.

Figure 6: Proposed Listing & Designation Effects on Residential Properties in CONUS



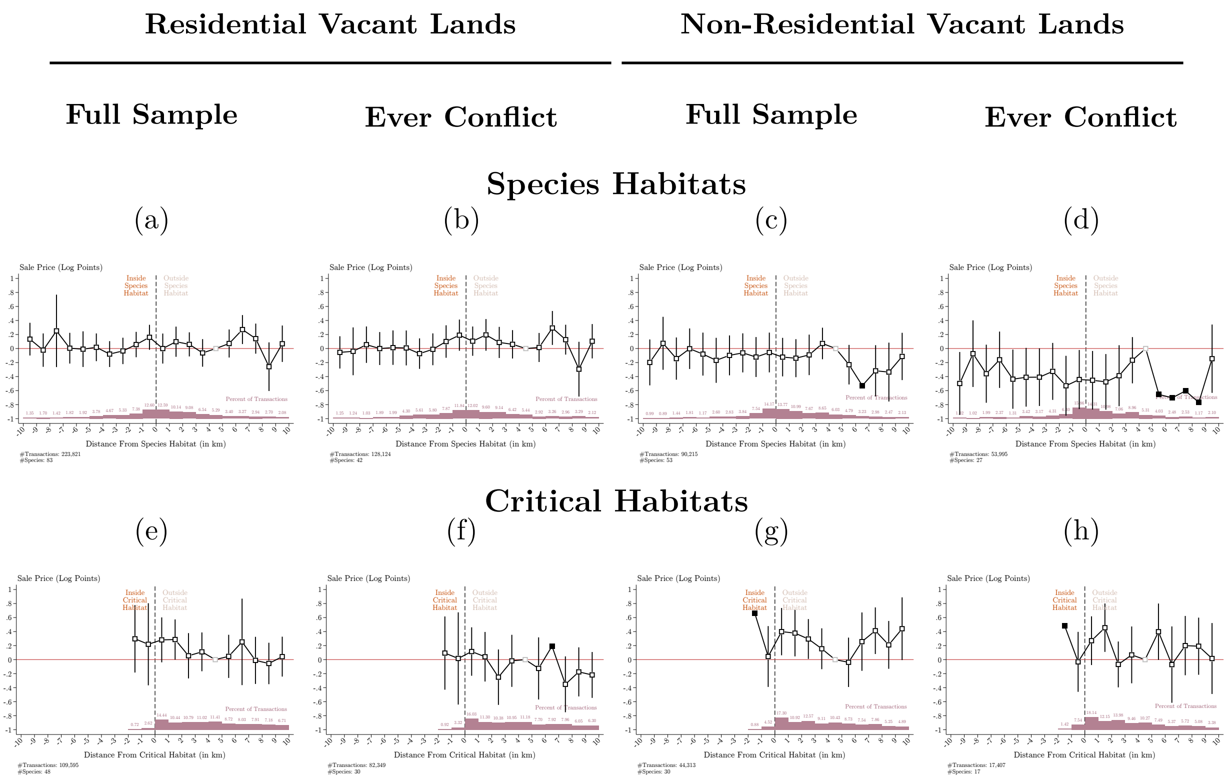

Notes: Coefficients and 95 percent CIs from Equations (1) and (2). The sample includes all transactions for properties 10km from the border of a species or critical habitat. Each regression includes ZCTA, species, listing history (see main text), controls for total number of rooms and area quintiles, as well as sample year and calendar month by FWS region fixed effects. Standard errors are clustered at the ZCTA level.

Figure 7: Proposed Listing & Designation Effects on Residential Properties in CONUS for Subgroups



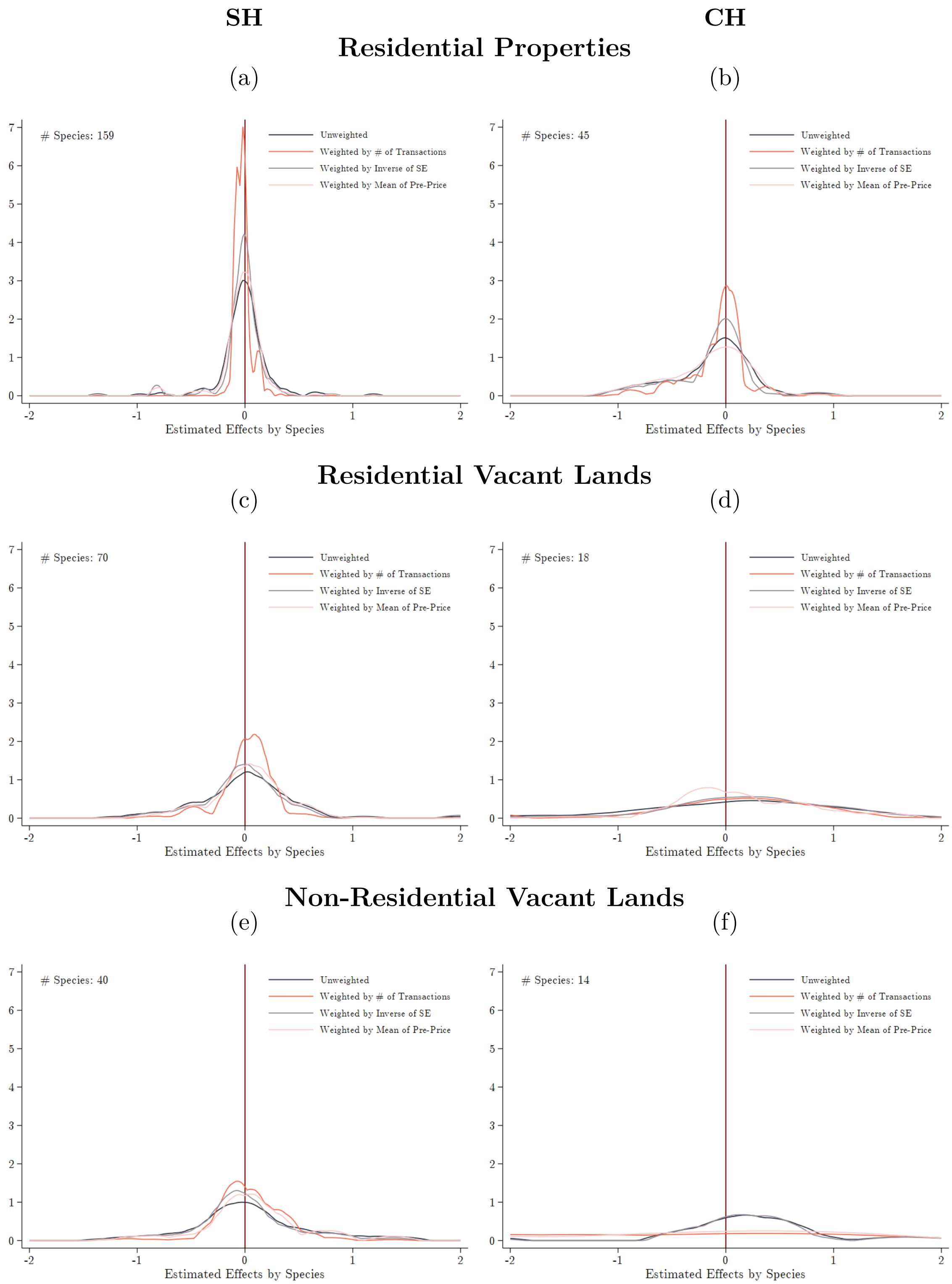

Notes: Same as in Figure 6, only for the five years before and after the proposed rules and subsamples.

Figure 8: Proposed Listing & Designation Effects on Vacant Lands in CONUS for Subgroups




Notes: Same as in Figure 6, only for vacant lands instead of residential properties and using the five years before and after the proposed rules for the full sample and the ever-conflict sample.

Figure 9: Proposed Listing & Designation Effects on Sale Prices by Species

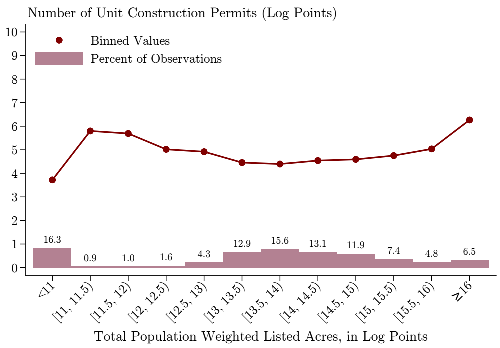



Notes: We plot kernel densities of coefficients obtained from estimating Equation (3), for the logged sale price, and interacting the post-inside coefficients with a species dummy. The sample spans five years before and after the proposed listing (for SHs) or the proposed listing and proposed designation (critical habitats). For easier visual inspection, we truncate the distributions at ±2.

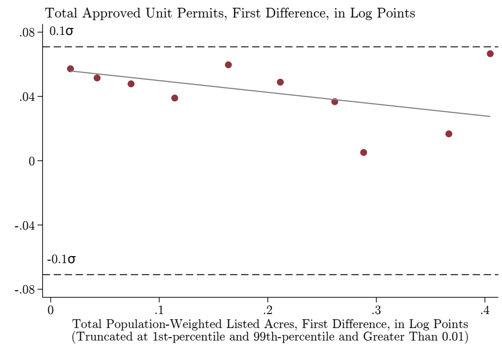
Figure 10: Construction Permits & Protected Acres

## Logs

(a) Total Listed Acres

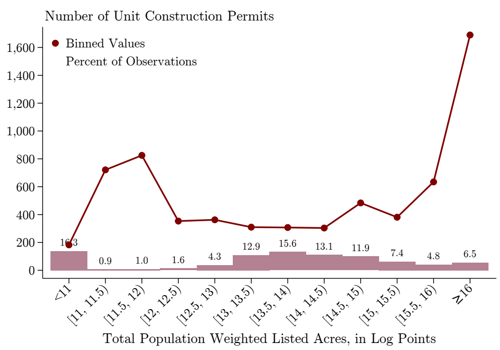



(b) Δ Total Listed Acres

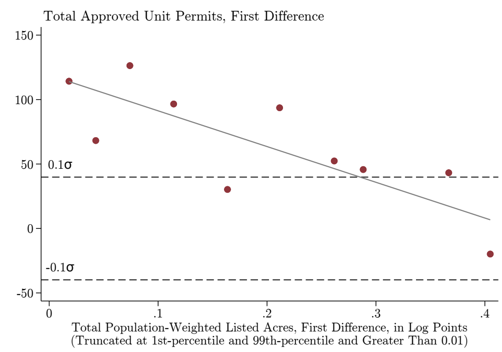



## Levels

(c) Total Listed Acres

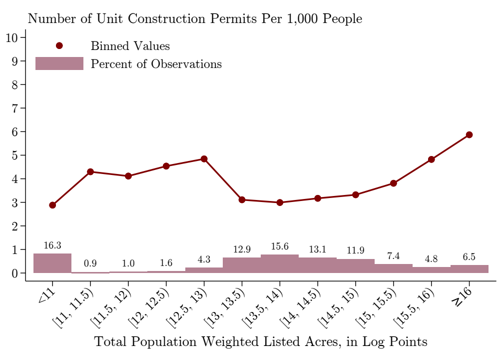



(d) Δ Total Listed Acres

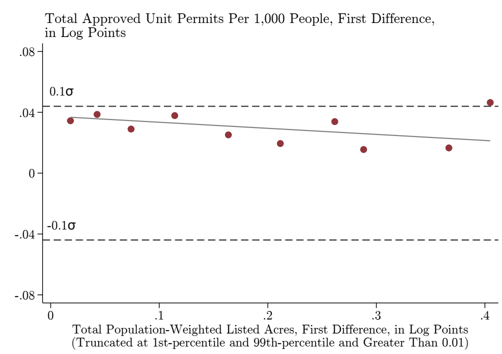



## Rates

(e) Total Listed Acres



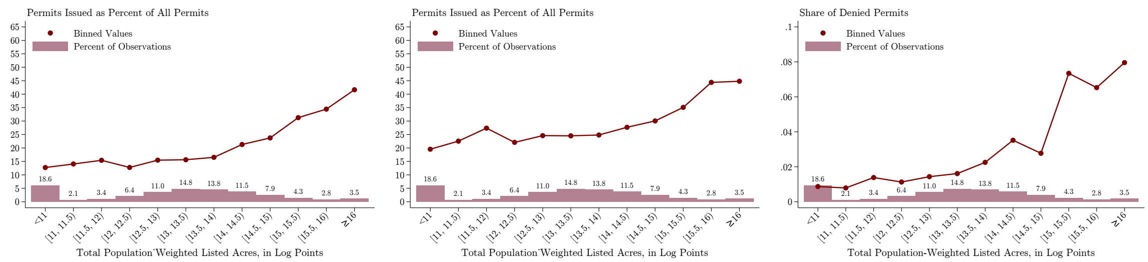

(f) Δ Total Listed Acres




Notes: Panels in the left column summarize construction permits (in logs, levels, and per capita rates) relative to the logged value of the total number of SH (population-weighted) acres, in equal-interval bins. We bottom- and top-code the bins at 11 and 16 to allow for easier visual inspection. Panels in the right column summarize the first differences of permits and protected acres using equal-density bins. We plot bounds of 0.1 standard deviation around zero on the y-axis to allow for easier interpretation of the slopes.

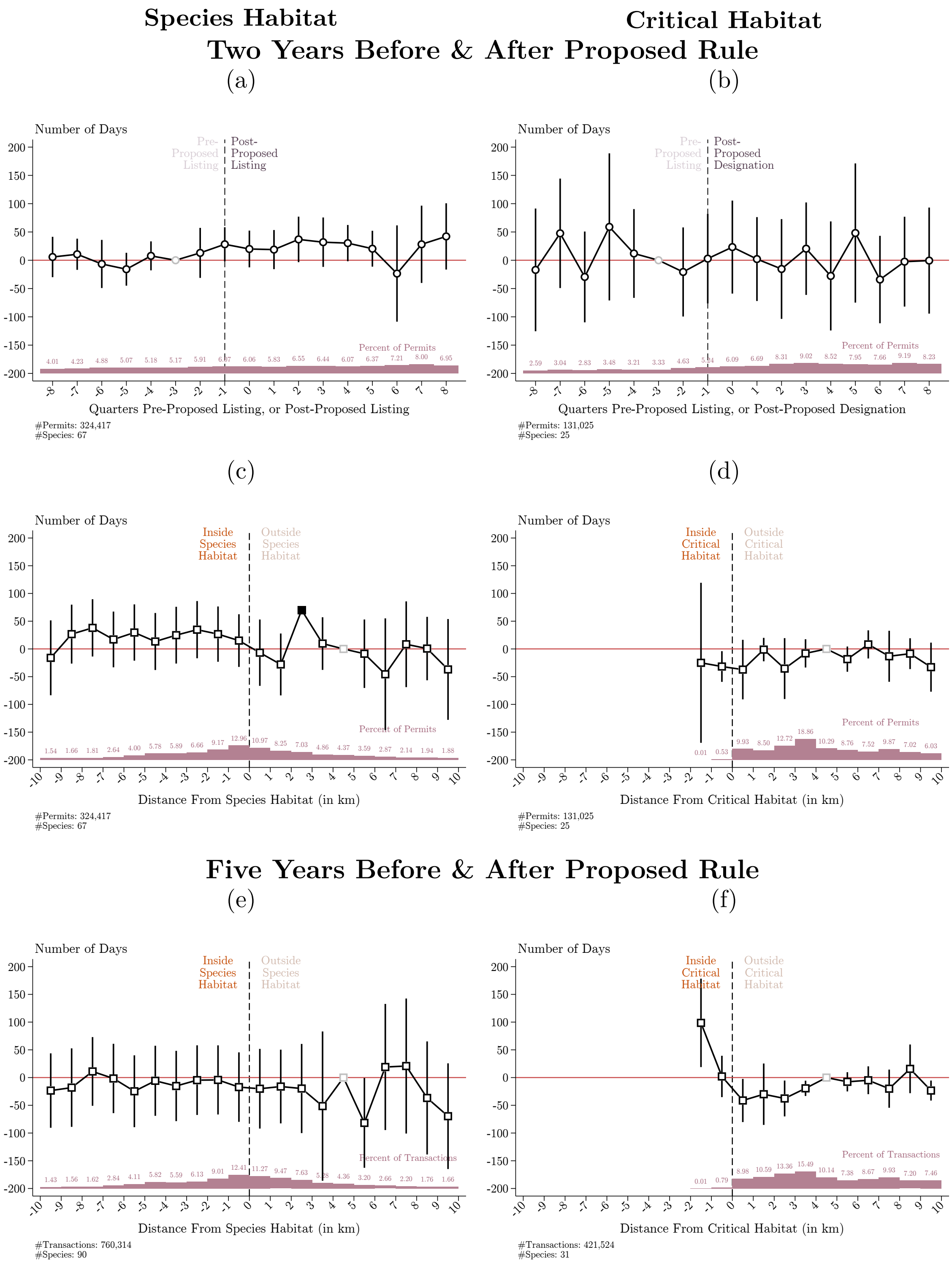
Figure 11: Army Corps of Engineers Permits in Near-Water Habitats

(a) % Special Conditions (b) % Standard Permits (c) Share of Denied Permits




Notes: Data at the county-year level for 2,839 counties, on permits issued by the Army Corps of Engineers (ACE) as a function of total listed SH area, weighted by population. We plot the composition of permits, measured as the percent, relative to all issued permits, of permits issued with special conditions (the action taken by the ACE), as permits issued as standard permits (the permit type issued by the ACE, which involves a longer processing period of approximately 120 days), or the share of permits that were denied.

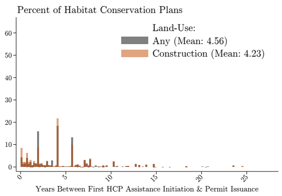
Figure 12: Proposed Listing & Designation Effects on Building Permits in CONUS



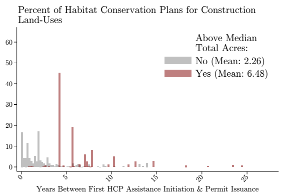

Notes: Same as in Figure 6, but instead of the outcome of the logged sale price, we use the outcome of the number of days between a construction permit application data and its issuance date.

Figure 13: Potential Delays From Habitat Conservation Plan Approvals

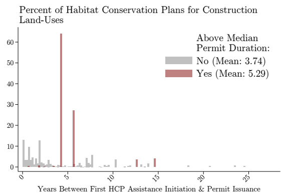
(a) Land-Use



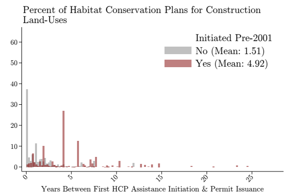

(b) Total Acres



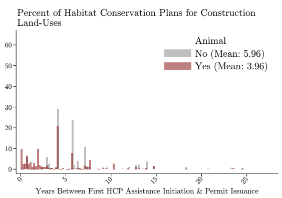

(c) Permit Duration



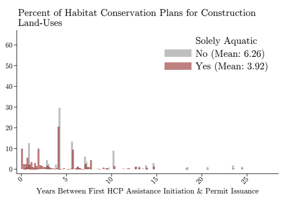

(d) Initiated Pre-2001



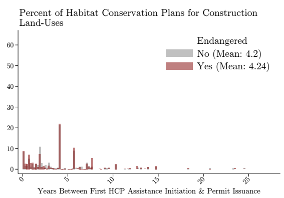

(e) Animals VS. Plants



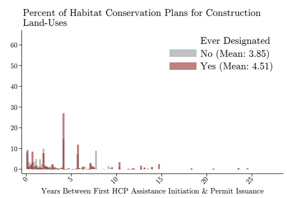

(f) Solely VS. Not Solely Aquatic




(g) Endangered VS. Threatened




(h) Designated Critical Habitats




Notes: The years between the first documented date and the approved date of a Habitat Conservation Plan.