The Cost of Species Protection: The Land Market Impacts of the Endangered Species Act*

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Abstract

Protecting species' habitats is the main policy tool employed across the globe in order 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). Using the most comprehensive data on species conservation efforts, land transactions, and building permits to date, we show evidence that the ESA affects land markets in measurable and economically significant ways. We show that the Act's most stringent habitat protections lead to an increase in the value of residential properties both on treated land as well as land just adjacent. We find an imprecisely estimated negative effect for vacant lands, with larger drops in value inside critical habitats. Our findings highlight that the impact on land values depends on the timing of statutory protection enactment and the land-use in question. Further, we find no evidence of the ESA affecting building activity as measured by construction permits. Overall, the number of possibly negatively affected parcels is extremely small, relative to the positively affected parcels, suggesting that the capitalization of the economic impacts of the ESA through the land market channel are likely positive despite the potential delays to development.

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1 Introduction

Monitored population sizes of mammals, birds, fish, reptiles and amphibians have dropped by an average of 68% over the past 50 years (World Wildlife Fund 2020). Out of the four million assessed species worldwide, roughly 25% are considered threatened and face extinction, often within decades (IPBES 2019). While to a degree species extinction is to be expected, current rates are estimated to be two to three 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).[1] Habitat loss is by far the most significant driver of extinction, as humans have altered seventy five percent of the land surface on Earth (IPBES 2019). Hence the protection of species habitat has become the most important policy tool globally in order to prevent species from following a path to extinction. Currently, 15% of global land area is formally protected (Protected Planet 2020). An effort under the auspices of the United Nations is underway to expand the area of protected land to 30%. Increasing the amount of protected land, which entails imposing restrictions on development, will likely be met with opposition from private landowners and developers, who are concerned about whether and to what extent this increased protection will cause a devaluation of their land or property.

The question of whether and to what extent habitat protection affects the economics of development is the central focus this paper. We examine the economic consequences of the 1973 United States' Endangered Species Act (ESA), which is the most extensive conservation legislation in US history. Understanding these economic impacts is of key importance as the ESA has served as a blueprint for conservation legislation in Australia, Canada, and Europe. There is similar legislation throughout most of Asia and Latin America. It is also the most controversial federal piece of environmental regulation to date (Shogren et al. 1999; List et al. 2006). Critics have raised concerns about costs imposed on private land owners, both in terms of delaying development and the lowering of property values.

[1] The three most important drivers of extinction are habitat loss, invasive species and pollution. All three are due to human activities that have accelerated at an unprecedented rate since the beginning of the industrial revolution.

This paper presents the first comprehensive national level economic assessment of the ESA, covering the universe of listed species for four out of five decades of the Act's existence. We have assembled the most comprehensive dataset on the spatial extent and type of ESA land restrictions for more than nine hundred species in the contiguous US, going back to the beginning of the Act. To estimate the causal economic impact of the Act, we have matched these data using space and time identifiers to the largest dataset on housing and land transactions (CoreLogic), as well as construction permits issued either by the county level jurisdiction, or by the Army Corps of Engineers (ACE).

In this paper, we test three specific hypotheses related to how the ESA may affect land markets. First, we test whether any ESA restrictions on land development lead to changes in housing values for properties located inside, outside, and proximate to the border of the species' protected areas. Second, we examine whether the listing of a species under the ESA itself has a measurable effect on the number and value of housing transactions and the issuance of building permits and habitat conservation plans. Third, we are the first paper to test whether the Act's most controversial aspect, the issuance of so-called critical habitat by the US Fish and Wildlife Service (FWS), has measurable impacts beyond the species listing.[2,3]

In order to identify the causal effects of the policy on our chosen outcomes, we employ three separate identification strategies. First, we employ a time series identification, similar to an event study, where we compare areas just before to just after policy treatment by aligning observations by treatment date, allowing us to identify the effect of the listing and designation. Second, we employ a before and after comparison inside and outside a treated area to separate the effect of ESA restrictions on properties located on either side of the

[2] The FWS considers critical habitats as "areas of habitat believed to be essential to the species' conservation." Source: https://www.fws.gov/endangered/what-we-do/critical-habitats.html. Accessed 12/23/2020.

[3] The FWS does not consider the designation of critical habitats as an additional level of protection, as they do not extend the scope or severity of the statutory protections already awarded by the act of listing the species. However, in practice, a critical habitat designation provides a spotlight to local regulators of where to focus their regulatory activity in order to minimize harm to species. Thus, critical habitat listing will likely result in greater stringency of regulation.

border. Furthermore, we allow for the effect of the policy to vary as a function of distance to the border- both inside and outside the designated area. Finally, in order to identify the effect of ESA restrictions on building permit activity, which for now we only have at the county level, we employ a two-way fixed effects model at the county level, where treatment is defined as a species-weighted-by-population-density share of county area.

In what follows we will show evidence of six main findings. First, we show that the number of sales in areas eventually designated as Critical Habitat (CH), the Act's most stringent restriction, is massively lower than the number of sales just outside these areas - both before and after designation. This suggests that the FWS draws these boundaries by taking into account local housing market characteristics. Second, we show that for the areas in the US for the areas in the US for which we have data on housing prices of properties located just inside *and* just outside the CH boundary, both increase relative to properties within five km of the boundary, and the effect is persistent. This finding is robust to considering multiple distance bandwidths around the border. Third, we show that this effect is largely due to the fact that areas *inside* the designated area saw increases in housing values. This appreciation inside the CH is suggestive of either an increase in amenity value mechanism, an increase in construction costs, in land scarcity, or all of the above. Fourth, we find a similar net effect for species listing - whereby parcels inside the species habitat see a smaller depreciation than parcels just outside resulting in a net appreciation inside versus outside. But while the level effect for critical habitat is an appreciation inside and outside, for species habitat designation we find depreciation of parcels inside and outside the boundary. Fifth, we show precisely estimated, yet extremely small effects of both species listing and critical habitat designation on construction permits nationally. Sixth, and finally, we document and quantify the burden imposed on developers in terms of the length of habitat conservation plans and heterogeneity therein.

This paper contributes to several distinct fields of literature in the broader economics discipline. Its most direct contribution is to the literature studying the impacts of the ESA.

The overall findings of this literature suggest a generally negative impact of ESA restrictions on land and property values. We find evidence to the opposite, as the results in the literature are likely driven by looking at the difference inside versus outside, which does not allow one to detect any effect of appreciation on both sides of the boundary, which is what we find. For example, Greenstone and Gayer (2009) find a small, negative impact on property values for properties located in plant species-specific critical habitat areas in NC, while Auffhammer et al. (2020a) and List et al. (2006) find negative impacts on values of vacant lands located in critical habitat areas. The evidence around the effect on permit issuance is somewhat mixed, however. For example, Zabel and Paterson (2006a) find a drop in short- and long-run permit issuance from the proposals of critical habitat areas in CA, whereas Sims et al. (2019) find a positive, but statistically insignificant, impact on permits from protected areas in New England.

Furthermore, there is evidence of pre-emptive development due to the designation of protected areas. List et al. (2006) find that the number of permit applications increases inside critical habitat areas just prior to final designation, due to an average pre-emption in the application of about one year. Similarly, Lueck and Michael (2003) estimate an increase in harvest probability of forest plots that are more likely to be protected, and attribute this increase to a pre-emptive land development in anticipation of listing or critical habitat designation. Finally, though not specific to the ESA, Bošković and Nøstbakken (2017) find that protected areas in Alberta, Canada cause a decrease in oil lease auction values, suggesting a negative economic impact of protected lands. This literature, though limited in species coverage and spatial scale, paints a picture of negative impacts from the designation of protected areas on local economies.

The analysis in this paper expands and builds upon previously documented effects of the ESA in several ways. First, we evaluate the effect at a national level, allowing us to find a representative effect across all listings and habitats. Second, we comprehensively estimate the effect of *both* habitat listing and critical habitat designation, in order to be able to identify the heterogeneous and separate effect of these protections. Third, our data include most years for which the ESA was implemented, thus allowing us to estimate the effect on property values and permits over a longer time span. Finally, our research estimates the effect of the designations and listings on properties that are located inside and outside of the boundary, thus allowing us to identify a heterogeneous effect at different distances to the border (both inside and outside).

Our paper also fits into the larger literature on the effects of land use and housing regulations on property values. This literature finds that land use regulations generally increase property values and decrease undeveloped land values through the restriction of housing supply (see Quigley and Rosenthal (2005) for a review of this literature), and that housing regulations tend to increase property values due to increased construction costs (see for example Glaeser and Gyourko (2003), Glaeser et al. (2005), and Quigley and Raphael (2005)). Our research estimates the effect of proximity to protected areas on housing prices; given the results of this literature, we may expect a positive effect on property values located proximate to, but outside of, the protected areas, if housing supply is restricted within the protected areas due to the protection. Furthermore, we would expect a potential decrease in properties located within the boundaries of the protected areas due to increased construction costs from the regulation.

However, protecting areas does not just restrict supply and increase costs of construction. Habitat protection also creates areas that are less or under-developed. Green, open, and undeveloped spaces have been shown to produce a positive amenity value for nearby properties that is incorporated into the value of those homes (see for example McConnell and Walls (2005) for a review of the literature on the effect of open spaces on property and land values; and Reeves et al. (2018) for a survey on the effects of conservation easements on neighboring properties). Conversely, proximity to a more developed area can also affect property values, either positively (such as shopping malls (Zhang et al. (2019)) or employment centers (Waddell et al. (1993))), or negatively (such as fast food restaurants (Drewnowski et al. (2014))

or developments that create more traffic (Colwell et al. (1985))). Thus, for properties that are proximate to, but outside of, the protected areas, our work will be able to identify the sum effect of restricted housing supply, increased amenity value of undeveloped nearby land, and reduced commercial activity. For properties within the border of the protected area, we will identify the net effect of decreased supply and nearby commercial activity, and increased development costs (or buyer expectations of increased costs) due to the protections placed on the land.

Methodologically, our paper adds to the large hedonics literature estimating the capitalization of (dis)amenities into property values. Beginning with the seminal paper by Rosen (1974), which established how markets reveal preferences for amenities through product price differentiation, the hedonics methodology has since advanced significantly. New techniques within the hedonics methodology include Tiebout sorting (an approach that takes into account the ability of homeowners to move across markets; see Kuminoff et al. (2013) for a survey of these papers); semi-parametric and non-parametric methods (an approach that allows for greater flexibility in the hedonic price function; see for example, Bajari and Benkard (2005) and Bishop and Timmins (2008)); and quasi-experimental difference-in-difference approaches (an approach that helps mitigate omitted variable bias by relying upon a quasi-random geographic distribution or timing of the treatment/amenity; see for example, Davis (2004), Chay and Greenstone (2005), Kuminoff and Pope (2014) and Muehlenbachs et al. (2015)). Our methodology fits into this latter group of quasi-experimental methods, as we leverage the exogenous staggered roll-out (both in time and space) of the ESA restrictions from the habitat listing and critical habitat designation across the country to identify the effect of these restrictions on property and land values.

In what follows, we provide an extensive discussion of the Act and its provisions, then proceed to describing the data, the empirical model, and estimation results. We posit that large-scale estimations such as this are needed to inform policy-making regarding the economic impacts of conservation decisions (Ando and Langpap 2018; Langpap et al. 2018), which will have ramifications for areas outside of the continental United States.

2 The Endangered Species Act & Restrictions on Private Property Development

The Endangered Species Act (ESA) was enacted in 1973 with a nearly unanimous vote.[4,5] The Act states its purpose as "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" (Endangered Species Act of 1973, Pub. L. No. 93-205, 87 1973). Two federal agencies are responsible for listing species as either "threatened" or "endangered," and to manage their recovery: the FWS and the National Marine Fisheries Services (NMFS).

Species gain protections under the ESA after either the FWS or the NMFS conduct a review process and find them "warranted" for protection. This process either starts due to an internal review process, a petition by a third party, or a court ruling. The agency issues a biological opinion based on "the best available scientific knowledge." Economic factors regarding the potential impacts of listing the species are expressly not taken into account at the listing stage.

The ESA provides the FWS and NMFS with 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.[6] Section 9 of the Act does, however, contain a provision exempting

[4] In the House, it passed with a vote of 390-12, and in the Senate, 92-0 (Mann and Plummer 1995)

[5] The Act was seen by many in Congress as legislation that was either trying to resolve a disagreement between the Departments of Defense and Interior regarding the protection of sperm whales, whose oil was used in submarines, or a needed step in implementing the recent ratification of the Convention on International Trade in Endangered Species (1995).

[6] There were two versions of the bill, one passing through the House and one through the Senate committees. The version that was adopted was mostly based on the one drafted by the Senate committee that removed the word "practicable." This is what allows the agencies to avoid taking into account economic considerations. This form of balancing mechanism is often found in other similar legislation (Mann and Plummer 1995). Another important difference is the definition of "taking" with respect to Section 9 of the Act. In the version passed by the House, the term "take" meant a direct injuring or killing of a listed species. In the version passed by the Senate the term included any action that could "harm" a listed species, allowing for a very broad interpretation of the ESA's anti-take provisions (Petersen 1999). As E. U. Curtis Bohlen, Deputy Interior Secretary, commented "[a]s the bill drifted through the Hill ... there were probably not more than four of us who understood its ramifications" (Mann and Plummer 1995).

persons from its restrictions in the event that compliance would cause "undue economic hardship."

Section 10 of the ESA allows for certain limited exemptions to the Act's prohibitions against private actions resulting in take. Notably, the Secretary of the Interior may issue permits to take listed species if the take is "incidental" to an otherwise legal activity.[7] Incidental take permit (ITP) applications must include a "habitat conservation plan" (HCP) detailing the expected effect on the species, how the holder will minimize and mitigate these effects, the alternatives considered and reasons for rejecting them. To issue an ITP, the Secretary must find that the taking will be incidental, the effects of the taking will be minimized and mitigated, the conservation plan is adequately funded, and the taking will not appreciably reduce the likelihood of the species' survival and recovery. HCPs and ITPs are frequently used by real estate developers operating on private land as a means of complying with the ESA when listed species are present.

Section 7 of the Act requires federal agencies to consult with FWS and NMFS to ensure that their activities will not adversely affect listed species or their critical habitats. Specifically, the Section 7 consultation process is meant to ensure that federal agency actions and private actions with a federal nexus (e.g., requiring federal approvals, permits, or funding) are "not likely to jeopardize the continued existence" of a listed species or adversely modify critical habitat. Before proceeding with the action, the federal agency must determine whether any listed species may be present and affected. Section 7 frequently impacts real estate development projects, resulting in project restrictions and costs on private land. For example, if development is slated to occur on land containing wetlands, then the developer must obtain a discharge permit from the Army Corps of Engineers (ACE) under Section 404 of the Clean Water Act. If the wetland contains endangered species (e.g., California vernal pools, red-legged frog, etc.), then the Corps must consult with the FWS before issuing a discharge permit. The Corps can only issue a permit once the planned development has

[7] Incidental in this setting means that the act of injuring/killing/harming a habitat or protected species happened despite the developer's best efforts to avoid it.

been modified to satisfy the FWS that listed species are not adversely impacted.

Concurrently with listing a species, Section 4(a)(3) of the ESA requires the Secretary—"to the maximum extent prudent and determinable"—to designate critical habitat for the species. Critical habitat is the area occupied by the species when it is listed that contains physical or biological features essential to the conservation of the species and that may require special management or protection, as well as specific areas not occupied by the species when it is listed that are essential for the conservation of the species. Critical habitat determinations must be based on the best scientific data available and account for economic effects, effects on national security, and other relevant effects. However, Section 4(b) allows the Secretary to remove areas from critical habitat if the biological benefits of designation are outweighed by its economic costs.

The ESA can impose costs on project developers on private land through the anti-take provisions of Section 9. The US Supreme Court's Sweet Home decision established that the definition of "harm" in the ESA can include habitat modification or alteration (Babbitt, Secretary of the Interior v. Sweet Home Chapter of Communities for a Great Oregon, 515 US 687 (1995)). Thus, when listed species are present, the ESA forbids project 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 the location of development, or redesign the project 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.

The designation of critical habitat can impose incremental costs beyond those associated with the listing of the species. In situations when critical habitat is presently unoccupied by the species, the requirements of Section 7 and Section 10 have traditionally resulted in additional costs to a project where none would be borne under Section 9's anti-take provisions.[8] Beyond the formal mechanisms established by the ESA, designation of critical habitat can be a signal to local regulators where habitat protections should be prioritized and impacts avoided. Local land use authorities typically have wide latitude to restrict or modify land development projects, and can alter requirements on the basis of a critical habitat designation.

3 Species Listings, Property Values & Permits Data

The analysis in the paper brings together data at a nationwide scale. In order to generate a comprehensive estimation of the effects of the ESA, we constructed a database on all the ESA events, by species, that can lead to, or form expectations of, land-use restrictions. We combine the ESA species events and habitat location data with geocoded transactions data, and data on county level construction permits. In this section, we briefly summarize each dataset, and provide a detailed account of how we obtained them; the Appendix provides ample information regarding the processing of the data. We summarize the the key variables used in the analysis in Table 1.

3.1 Listing of Species Under the Endangered Species Act

The ESA provides us with a 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 to designate a critical habitat. We construct the full history of Proposed and Final Rules by using the FWS Species Data Explorer API. Furthermore, we manually collected and extracted the information on dates for proposals and decisions from the publications in the Federal Register to supplement any missing data from the API data set. We focus our

[8] In 2018, the US Supreme Court ruled that an area is eligible to be designated as critical habitat under the Endangered Species Act (ESA) only if the area is habitat for the relevant threatened or endangered species. The Court vacated the US Court of Appeals for the Fifth Circuit's decision, which held that the ESA has no habitability requirement, and remanded the case to the Fifth Circuit to consider the meaning of habitat under the ESA. Thus, land can no longer be designated as critical habitat if it is currently unoccupied by a listed species.

attention on species in the contiguous US that are managed by the FWS and not by the National Marine Fisheries Service.

The timing of the listings is staggered, and often concentrated in small batches where several species receive a Proposed and Final Rule on the same day. We interpret this staggered pattern as indication that there is some degree of uncertainty regarding the exact timing of when ESA restriction might apply to a land area. See Figures 1a and 1b for a summary of the time between a Proposed and Final Rule for each species. This provides us with a time series of locally specific shocks to land-use restrictions as a result of all ESA regulations that apply under Sections 7 and 9 of the Act.

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 critical habitats for the listed species, which we have obtained, processed and matched to the listing and designation dates. We use these to define the treated areas. See Figures 1c and 1d for the areas that were under some form of ESA statutory protections by decade, for either species habitats (due to listings), or critical habitats (due to designations).

3.2 Property Transactions

Data on property transactions that include the exact location of the property and the date of sale allow us to study how land markets respond to ESA regulations. We obtained transaction data from the CoreLogic Tax and Deed Data. This dataset provides us the location, timing, and sale prices over time, thereby allowing us to assign transactions with either a pre-treatment or post-treatment status, as well as either an inside or outside the protected area status. The CoreLogic dataset allows us to study earlier ESA regulations as it covers 1976 to 2018.[9] We exclude records with either a missing location, date of sale, or

[9] The range of years in the data differ across states. Some states have many more years of data than others. See the Appendix for more details.

price, and filter out any non-arms-length transactions.[10] We are left with over thirty-two million residential records and over three million vacant land records that are within 10 km of a critical habitat border, and over sixty-eight million residential records and over six million vacant land records that are within 10 km from a species habitat border.

In Figure 2, we summarize the number of transactions inside and outside the border of species and critical habitats, before and after the listing or designation event. In the case of designations, there is a clear discontinuity at the border. There are more transactions that take place outside of the border, both before and after the designation. This is consistent with the fact the FWS can consider non-biological considerations when they demarcate the border. After both listings and designations, transaction counts do not appear to decline inside the border. This empirical observation stands in opposition to the notion that ESA regulations apply severe land-use constraints that drastically reduce land development.

3.3 Construction Permits

To study the potential effects that ESA regulations have on housing supply, we use data on construction permits from the US Census, as well as data on construction permits for works on the Nation's water area from the Army Corps of Engineers.

3.3.1 Building Permits Survey

We obtain county-year level data on new residential construction permits from the US Census Bureau's Building and Permits Survey (BPS), an annual mail survey of permit-issuing jurisdictions. This provides the total number of approved residential housing construction permits for buildings and units, spanning 1990 to 2019 for each county in the United States.[11] We use data from the coterminous United States. To capture undeveloped parcels' average exposure to protected lands, we aggregate critical habitat and species habitat area within a

[10] We use different flags in the data sets to remove non-arms-length transactions, and remove any transactions that have a sale price below USD 1,000.

[11] The data include both, as a building might have several units.

county using population weights. We also calculate the unique protected area in the county to avoid double-counting protected land covering multiple species. Finally, we calculate the share of each county under protection.

3.3.2 Army Corps of Engineers Permits

Permits issued by the US Army Corps of Engineers (Corps) authorize various types of development projects in wetlands and other waters of the United States. Individual permits are a key component of Corps permits and target significant actions that have more than minimal individual or cumulative impacts on the waters and wetlands. The focus of our analysis is individual permits, and we use terms "Corps permits" and "individual permits" interchangeably in the paper. More details on the permit process can be found in the appendix.

The decision to issue or deny an individual permit is based on the public interest review and an analysis of the ocean dumping criteria. An individual permit can possibly get three types of decisions: 1) issued without special conditions, 2) issued with special conditions, and 3) denied. The Corps may add special conditions to the permit to ensure that the activity does not jeopardize related laws, including the Endangered Species Act.

Data on the Corps permits are obtained from two sources. The data post-2008 come from the Corps regulatory data management system, which summarizes georeferenced records on final and pending permits from every district and division. We obtain the data of the same format between 1990 and 2008 through a FOIA request to the Corps.

We aggregate the two datasets into a county-year panel ranging from 1990-2019, and construct variables on the total number of Corps permit applications and the share of permits across final decisions. Similar to the panel construction of the construction permits data, the critical habitats and species habitats are aggregated in a county-year panel using population weights. The final data set covers 2,829 counties and spans 1990-2019.

3.4 Habitat Conservation Plans

Habitat Conservation Plans (HCPs) are required for private parties who intend to undertake projects that may result in damages to endangered and threatened species. We obtained the data on HCPs through a FOIA request to the FWS. The data cover complete information on all conservation plans submitted to the FWS since the early 1980s, including the applicant, the location of the plan, the area acreage covered, the listed species, the status of the plan, the intended land use, as well as the dates indicating when the first assistance regarding the plan started, when the application was received and when the permit decision was made. We link the HCP data with the listing status of endangered and threatened species and the designation status of critical habitat. We measure the timeline of a plan by the number of years between the date an applicant first initiates an assistance regarding the plan and the date the final decision regarding the permit is made. We also construct dummies on whether the HCP submission is before the designation of the critical habitat, on the listing and designation status, as well as on the type of the species. The final dataset covers 7,851 unique HCPs in the contiguous US, spanning 1990-2020.

4 The Impacts of the Endangered Species Act on Land Markets

In order to causally estimate the economic impacts of the listing or designation under the Endangered Species Act (ESA) on the market value of a parcel of land, one would ideally assign habitats for endangered species as protected randomly across space and time - mimicking a randomized controlled trial. This is clearly not feasible in reality as habitats are proposed and possibly assigned via a lengthy regulatory process as discussed in Section 2. This complex process commences with there being information about a species' possible high extinction risk in the absence of statutory protections. The exact timing of when that process starts, and whether and when a species moves forward in the process, in the form of either a Proposed or Final Rule, is uncertain. But of key importance to this paper is the fact that it is not easy for individual private landowners to manipulate that process.

Our approach to econometrically identify the economic impacts of the ESA compares properties on both sides of the spatial boundaries of either species habitat ranges or critical habitats, 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 as well as the distance to the border. This flexible approach allows us to test whether the effect of the listing/designation affects properties fully contained inside the habitats in a different manner than those outside the borders. We allow the impact on parcels to vary by distance to the habitat's border, thus capturing heterogenous effects by distance of the newly imposed land-use restrictions. We examine these effects overall, as well as separately for vacant lands, agricultural lands, and residential properties already in place at the time of the listing.

When estimating the effects of ESA protections, we pay careful attention to the onset of treatment, and to 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 habitat, which possibly affect the market's valuation of individual parcels. Consequently, there are four periods that can be considered as the beginning of treatment: the proposal of a species' listing/designation or the finalization of a species' listing/designation. Just as each step of the ESA process over time can have a differential treatment effect, it is also the case that 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 the protected area are only affected *indirectly* by the enactment of protections (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 ten km from the border of the protected area.

Throughout the analysis, we hold the definition of the pre-treatment period constant, but consider different definitions of treatment onset. We regard the pre-treatment period as the time before there is any proposed rule to either list or designate. Onset of treatment is defined as a specific ESA event (the proposal of a species' listing/designation or the finalization of a species' listing/designation). This allows us to test whether proposal has a statistically different impact, if any, from the finalization of species protection. In order to identify the effect of the different stages of ESA protection, we always compare the post-treatment set of parcels to the pre-treatment set of parcels, dropping from the analysis the "in-between" parcels. For example, to identify the compounded effect of all events up to and including *critical habitat designation* on property values, we drop parcels that are sold between the date of the proposed species listing and the date of the final critical habitat designation. This allows us to cleanly compare pre- and post-event each of the individual stages of ESA protection. We schematically summarize the research design in Figure 3.

As discussed above, statutory protections that result in restrictions on land-use can spill over to properties outside the protected area. These indirect effects can operate in opposite directions to one another. Properties that are outside, but near, the protected area can either see their values appreciate, depreciate, or remain unchanged. If open spaces are valued as positive amenities, ESA protections could increase property values for the parcels outside the protected area (Irwin and Bockstael 2001; Geoghegan 2002; McConnell and Walls 2005; Anderson and West 2006; Black 2018; Fernandez et al. 2018). However, if amenity value of parcels outside is more determined by availability of services provided by developed parcels (e.g. open malls, cafes, gas stations etc.) then property values near the border could decline (Colwell et al. 1985; Waddell et al. 1993; Drewnowski et al. 2014; Zhang et al. 2019). Another mechanism through which land-use regulations can affect values outside the protected area works through its possible reduction of local housing supply. As a result, prices of properties outside the protected area could go up due to the higher scarcity in land that can be developed (Glaeser and Gyourko 2003; Glaeser et al. 2005; Quigley and Rosenthal 2005; Quigley and Raphael 2005; Ihlanfeldt 2007). Finally, development outside the protected area is not subject to the same constraints as within. This could place a premium on these properties and land parcels following the enactment of statutory protections for species. Using data on construction permits, we also investigate the role of species protections on housing supply below.

In summary, we study the net effect of ESA regulations on land markets using three techniques. First, we employ a staggered difference-in-differences design, where we compare the transaction values of properties inside and outside, 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 differences-in-differences, 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 listing/designation, are driven by depreciation/appreciation inside the protected area, or appreciation/depreciation outside. Third, we use variation in the amount of land under ESA statutory protections to examine changes in construction permits and housing values. Specifically, we use two-way-fixed-effects (TWFE) regressions where we use either the amount or share of land that is under protection, or the number of species listed or designated that have their habitats overlap with the unit of analysis.

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 develop along parallel trends. There are two main potential confounders we need to consider in terms of the bias they might introduce to the analysis. One key confounder 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 their growth. Combined, we can sign the effect of this confounding element to have a negative bias, resulting in attenuated estimates. The second confounding factor relates to the designation of critical habitats. The FWS can take into account economic factors when deciding which parts of the species habitat to designate as critical habitats (though it cannot do so for the species listing decision). This means the FWS might not designate highly valuable lands as critical habitats. If that is the case, which is a very plausible one, then we are recovering a lower bound of the effect, as the highest value transactions are not affected by the designation. 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 species habitat and the timing of the listing.

4.1 Main Regression Specifications

4.1.1 Staggered Difference-In-Differences

Variation in the timing of the enactment of statutory protections across species provides us with multiple pre- and post-listing or designation comparisons. We conduct a staggered difference-in-difference (DD), whereby the treatment effect occurs at different times for each protected area.[12] We use the natural logarithm of the transaction price, ln(Sale Price$_{izcsdbt}$), for property i, in ZCTA5 z, in county c, in state s, with distance d to the border b, in year y and month m.[13] The following DD specification estimates the effect of enacting ESA protections on properties inside relative to those outside the protected area, before and after

[12] Staggered difference-in-difference methodologies are frequently used in economics (Autor 2003; Stevenson and Wolfers 2006; De Janvry et al. 2015; Alacevich et al. 2021). More recent literature in this space has identified concerns with commonly used staggered DD methods. The primary concern is that the two-way fixed effect estimator is a variance-weighted average of treatment effect parameters, and, in the presence of heterogeneous treatment effects, can produce negative weights, thus resulting in incorrect estimates of the average treatment effect. Methods to diagnose negative weights in a staggered difference-in-difference 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 (2020), De Chaisemartin and D'Haultfœuille (2020a), and De Chaisemartin and d'Haultfoeuille (2020b). Future versions of this paper will use these newly developed diagnostics and estimators to test the robustness of our estimates to the presence of heterogeneous treatment effects across groups and over time. Furthermore, similar to the approach utilized in Cengiz et al. (2019), we run separate regressions by species, and report them in the Appendix, to examine the composition of the effects that are weighted in our estimate of the average treatment effect (ATE).

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

the protections apply.

$$\ln(\text{Sale Price}_{izcsdbym}) = \sum_{\substack{\tau \in \{\underline{T},\dots,\overline{T}\} \\ \tau \neq -1}} \mu_{idb\tau}(\pi_\tau + \beta_\tau \omega_{idb\tau}) + \omega(\text{Inside})_i + \\ \phi_z + \rho_{yr} + \eta_{rm} + \alpha_b + \boldsymbol{X_{it}\theta} + \varepsilon_{izcsdbym} \tag{1}$$

Where $\mu_{idb\tau}$ equals one when the transaction is τ quarters from the event of interest, either a listing or designation event. A key deviation here from the more standard application of a staggered DD is that we perform a double re-centering around pre- and post-treatment. The pre-treatment period (from period $\underline{T}$ to period 0) is the time before any Proposed Rule is published regarding the species. Event time up to the first Proposed Rule is measured in negative values. The positive values of the running event time (from period 0 to $\overline{T}$) start after the event we consider as the treatment onset of interest (e.g., the Final Rule to designate a critical habitat). This means we look at the quarters before the first public proposal, and the quarters after a specific event of interest. Because the number of quarters between the two events is not equal across species, and because there can already be effects on land values after the first proposal, we omit the time periods in between. The only case where we do not exclude time periods this way is when we consider treatment onset as the first Proposed Rule to list the species, as there is no gap between the pre-treatment and post-treatment periods.

The specification in Equation (1) estimates the dynamic development of transaction prices for properties inside relative to properties outside the protected area. We include two sets of leads and lags, one that is estimated for properties inside and outside the protected area, and one set that we interact with $\omega_{idb\tau}$, a dummy variable that equals one when the property is inside the protected area. The set of coefficients, β_τ, measure the dynamic development of transaction prices that is different for properties inside the protected area, whereas the set of coefficients π_τ measure how prices change over event time for properties inside and outside the protected area. The dummy variable, $(\text{Inside})_i$, equals one for properties that are inside the habitat, and zero otherwise.

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, ϕ_z. This controls for any areas that are predominately more rural relative to urban, or have higher development opportunities. Furthermore, this helps mitigate the omitted-variable bias by controlling for unobservables at a very localized level.[14] To account for pooled time effects, we include sample year-by-FWS-region fixed effects, ρ_{yr}, to flexibly control for time trends, and calendar month-by-FWS-region fixed effects, η_{mr}, to flexibly control for seasonality.[15] The fine-scaled time fixed effects allow us to more accurately capture real business cycles or changes in local conservation efforts and legislation. In order to better compare across listings and designations, we also include a species fixed effect, α_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 linear terms for the size of the lot, the total number of rooms, the total number of bathrooms, and a set of dummies for the age of the property.

4.1.2 Spatial Difference-In-Differences

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 utilizing a spatial difference-in-difference approach (Kiel and Zabel 2001; Currie and Walker 2011; 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/regulation. To this end, we modify the specification in Equation (1) to focus on changes in distance bins

[14] Kuminoff et al. (2010) demonstrate how including spatial dummies in a difference-in-difference framework improves the estimation of marginal willingness to pay in a setting with time differentiated data.

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

of one km, before and after the onset of treatment. We allow the effect to vary up to 10km distance on either side of the protected border.

$$
\begin{aligned}
\ln(\text{Sale Price}_{izcsdbym}) = & \sum_{\substack{k \in \{\underline{k}, \dots, \overline{k}\} \\ k \neq k_0}} \lambda_{idbk}(\gamma_k + \delta_k \psi_{idbk}) + \nu(\text{Post})_{ym} + \\
& \phi_z + \rho_{yr} + \eta_{mr} + \alpha_b + \boldsymbol{X_{it}\theta} + \varepsilon_{izcsdbym} \qquad (2)
\end{aligned}
$$

Where λ_{idbk} equals one when a 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 set of dummies, but this time for distance bins and not leads and lags. The first set of distance bin dummies capture the average transaction price from the border as a function of distance, both before and after the enactment of land-use restrictions. The second set is interacted with a dummy, ψ_{idbk}, that equals one when the transaction takes place after the onset of treatment. The coefficients of interest, δ_k, measure how prices change around the border after the land-use restrictions apply. The dummy variable, $(\text{Post})_{ym}$, is equal to one for time periods after the treatment onset, and zero otherwise. This specification allows us to directly test for any SUTVA violations in the form of spillovers on the properties that are outside the border of the protected area. All other variables are the same as in Equation (1).

4.1.3 Two Way Fixed Effects

Equations (1) and (2) produce flexible estimates in either the time or distance dimension. We also estimate a pooled version of the inside relative to outside the protected area, before and after the treatment onset:

$$
\begin{aligned}
\ln(\text{Sale Price}_{izcsdbym}) = & \beta_1(\text{Post})_{iym} \times (\text{Inside})_{ib} + \beta_2\text{Post})_{iym} + \beta_3(\text{Inside})_{ib} + \\
& \phi_z + \rho_{yr} + \eta_{mr} + \alpha_b + \boldsymbol{X_{it}\theta} + \varepsilon_{izcsdbym} \qquad (3)
\end{aligned}
$$

Where $(\text{Post})_{iym}$ is a dummy variable that equals one after the treatment onset, defined as either the listing proposal date, final listing date, designation proposal date, or designation final date. We interact the post-treatment dummy with the treated dummy group of $(\text{Inside})_{ib}$, that is equal to one for properties that are inside either the critical habitat or species habitat. We estimate this regression either for the pooled sample, or by species. All other variables are the same as in Equation (1).

5 Main Land Market Outcomes Estimation Results

5.1 Estimating Effects on Land Markets From Critical Habitat Designations

Following previous work that has focused on the impacts of critical habitats (Auffhammer et al. 2020b; Lueck and Michael 2003; Zabel and Paterson 2006b), we first review the effects from designations, and then proceed to estimate the effects of listing more broadly. Below, we break down results by whether a parcel has a residential structure on it or whether it is vacant for the different estimation strategies described in the previous section. We focus on non-aquatic species here, as for most rivers and lakes there is no "inside." We discuss aquatic species in the context of the spatial DD separately below.

5.2 Results for Critical Habitat Designations

5.2.1 Residential Properties

We start with the results for single- and multi-family residential properties located near the border of a critical habitat.[16] For the full sample of properties sold in the contiguous US, we compare properties sold before the first proposal to *list* a species, and after the final

[16] The current results do not control for property characteristics beyond the fixed effects discussed in the previous section as we will only gain access to these data in August 2021. A future draft of the paper will naturally control for observables.

designation of critical habitats using the staggered Difference-in-Differences design. In panel (a) of Figure 4, we show that properties that are sold inside critical habitats, up to ten km away from the border, see an average sale price that is five to ten percent higher than properties sold outside the critical habitat area, after the critical habitat designation (Figure 4 reports the coefficients β_τ from Equation (1), which represent the interaction of distance to border and post-designation). Our estimates of Equation (1) suggest that designation of critical habitats leads to an appreciation of residential parcels inside the protected area over parcels located outside of it, yet the effect using the national sample of over a million sales and 109 species is not precisely estimated and hence we cannot rule out a zero effect. Panel (b) in Figure (4) shows results from estimating Equation (1), once we limit our estimation sample to the Pacific Southwest, which includes the state with more than half of our sales - California. This limits the number of species to 55, yet accounts for 58% of our residential transactions. For this sample, we find a statistically and economically significant post-designation appreciation of parcels inside versus outside on the order of 20%.

For the species that receive a critical habitat designation, we also examine how transaction prices respond to the proposed rule to list the species. In panel (c) of Figure A1, we report the results when the treatment onset is the proposed rule. There appears to be a similar positive effect on prices due to the announcement of the proposed rule to list a species. The coefficients for the first four quarters after the proposed listing for properties located inside the listing areas increase imprecisely by 5-30 percent relative to those properties outside the area. A difference in prices, especially four quarters out, is consistent with the summary of data in Figure 1b that shows that there is a spike in final rules for listings around one year after the proposed rule.

In the results so far, we have focused on how prices develop inside versus outside a critical habitat, before and after different potential treatment onsets. While we observe that prices are different (especially in the Pacific Southwest), this can be consistent with multiple mechanisms. As we discussed in Section 4, differences in prices around the border could be the result of either appreciation inside the border, or depreciation outside the border, or differential magnitudes of appreciation or depreciation on both sides. To better examine which is driving the results we observe over time, we shift our attention to study how prices change as a function of distance from the border.

We report the results from the spatial-DD regression specification in Equation (2) in Figures (5) and panel (f) of Figure A1 following the final designation and proposed designation, respectively. Properties that are both outside and inside the border of the critical habitat sell for higher values after the proposed designation or the final designation the closer they are to the border, relative to properties that are five km away from the border. About one km away from the border, the price increases are precisely estimated and are economically meaningful, with outside properties selling for ten percent more relative to the selling price during the pre-treatment period and properties inside selling for up to twenty-five percent more. The results do not change substantively by expanding the sample to include all transactions (in time). We still see a significant appreciation inside and outside of the border, although the results do not appear to be driven by observations in the Pacific Southwest.

The spatial DD design hence suggests a story where property values increase on both sides of the border, but more so on the inside than on the outside. This provides context for the staggered DD results above. As properties on both sides of the border appreciate, the appreciation we showed is driven by properties on both sides, not by an asymmetric response at the border. We also note the anemically low volume of transactions, less than one percent, inside the critical habitat that we document in Figure 2, both before and after designation. The magnitude of the difference in sale price for properties sold right outside the border relative to inside the border suggests that most of the effect we estimate in the time staggered-DD specifications is driven by properties outside. These results still do not allow us to disentangle the mechanism that is driving prices up (e.g. higher amenities versus lower housing supply). We explore the role of the housing supply mechanism in the following section on construction permits.

The results discussed here used transactions for non-aquatic species only, as habitats for aquatic species are mostly lakes and rivers. While a lake is a polygon and hence technically has an "inside", it is hard to build on most lakes lacking islands. It is similarly difficult to build on a river. We hence report results for aquatic species separately and only estimate "outside" effects. These results are reported in panel (a) of Figure (A2). For these species we see a relatively precisely estimated zero effect on property values just outside the critical habitat. This is consistent with an amenity value story, whereby not much changes in terms of easily visible or detectable characteristics of the land adjacent to the outside parcels, as relevant amenities - such as river water quality - are fewer and possibly of lower market value compared to more open space.

5.2.2 Vacant Lands

We proceed to evaluate the effect of designations on the property value of vacant land transactions. CoreLogic labels each transaction as to whether it is vacant land or not, and we make direct use of this classification of vacant lands. Vacant lands are economically meaningfully different from the residential transactions in a single important dimension - they can be used to build new structures on and hence arguably have the highest development potential. As Auffhammer et al. (2020a) point out, placing restrictions on vacant lands imposes economic costs on developers of such lands. One would hence expect that these vacant lands decrease in value in areas with restrictions (inside) relative to areas without restriction (outside). We conduct the same estimation as in the previous section, yet restricting our estimation sample to vacant lands only, which results in a significant reduction in sample size, especially inside critical habitats. There are two key findings with respect to these areas as shown by Figure 6.

First, after the final designations, vacant lands in the vicinity of the border see a large, yet imprecisely estimated reduction in their sale price. This finding is not robust to expanding the sample to include all transactions in time. Panel (b) shows an imprecisely estimated appreciation outside of the critical habitat after designation and an imprecisely estimated decrease just inside the border. When we conduct the same estimation examining proposed designation in panel (l) of Figure A1 the patterns are similar to those for final designation - an imprecisely estimated decrease in value. After a final designation, sale prices fall by as much as fifty percent for properties inside the critical habitat. This effect is imprecisely estimated, and we only observe these declines for properties that are three km away from the border.

5.3 Estimating Effects on Land Markets From Species Listing Decisions

As previously discussed, critical habitats are a subset of the species habitats, and not all species receive a critical habitat designation. In this section, we study the effect of awarding statutory protections under the ESA through the listing of species. However, as the habitats of listed species cover larger swaths of land (see Figure 1c) relative to critical habitats, they also tend to overlap. This complicates the analysis of listings because each land parcel might overlap with several species habitats. This introduces two important features: (i) As more species become listed in a given area, a land parcel might experience a greater probability of facing binding land-use constraints; and (ii) When we evaluate the effect of a specific listing we also need to account for any previous listings when constructing the comparison group.

To account for multiple overlapping species habitat listings we define the listing history group for each property transaction. Explicitly, for each transaction that is within 10 km of a species habitat border for listing L, we record all previous listings, $L-1, ..., 1$, in that location. We modify Equations (1), (2), and (3) to include a listing history group fixed effect. The history group fixed effect allows us to compare within a set of land parcels that shared a similar ESA history of regulatory listing actions. The residual variation within each history group is composed of a treatment group within the species habitat, a comparison group that is outside the species habitat, before and after the listing proposal or final listing rule.

The estimation of Equations (1), (2), and (3), with the included history group fixed effect, recovers an average treatment effect for different listing history lengths. For example, parcels that shift from no prior listing to experiencing their first listing event are averaged together with parcels that experience their sixth listing. To examine the heterogeneity across listing history lengths, we again modify Equations (1), (2), and (3) and interact the coefficients of inside, post, and their interaction, with a set of dummy variables for history lengths of one to ten, and above eleven listings.

5.4 Results for Species Habitat Listings

The estimates for the species habitat listings recover substantially different results than the critical habitat designations. We estimate the staggered and spatial DD specifications, including a listing history group fixed effect accounting for previous listing events experienced by the land parcel, and report the results in Figure 7. Using the staggered DD estimator for residential properties, we find that relative to five km away from the species habitat border, prices within three km to the border imprecisely drop by two to five percent after the final listing. For vacant lands, we find that prices imprecisely appreciate inside relative to outside the species habitat. This appears to be mostly driven by the concentration of transactions around the species habitat border, where parcels just outside see a slightly larger depreciation compared to parcels just inside; the same is true in the case of vacant lands given the estimated imprecise depreciation of the vacant land parcel right outside the species habitat.

In the case of species habitats, we observe more transactions on either side of the habitat borders, relative to the critical habitat borders (see Figure 2). We leverage the larger density and estimate the staggered and spatial DD specification for a sample of repeating sales, defined as parcels sold more than twice but less than five times.[17]

[17] We exclude properties sold more than five times in order to avoid including properties with any unobserved abnormal characteristics in the sample.

In Figure 8, we report the results for residential properties in the repeated sales sample, both with and without including a parcel fixed effect. The results without the parcel fixed effect allow us to evaluate the sample composition difference in the results relative to the non-repeated sales sample. Including a parcel fixed effect controls for any characteristic of the house that might remain the same between its multiple sales such as the number of rooms, size of the house, and nearby amenities. Overall, we recover similar effect in magnitude and precision to those reported in Figure 7.

Throughout the analysis, we often limit the sample to a four-year window, two years before any listing proposal for the species, and two years after either the final listing or the final designation. This allows us to focus on time periods where the ESA effects are more likely to be the most recent and largest effect on local land markets. However, it also means we are focusing on short-term effects following the listing or designation, and that we establish the baseline land market conditions using only two years of data.

To capture longer-term effects, and to use more years of data to inform the baseline condition in the local land markets, we utilize all the observations in the sample. In Table 2, we summarize the estimation results from the TWFE specification in Equation (3). For either residential properties, or vacant lands, we decompose the average post-treatment effect to two parts: post-listing-proposal, and either post-final-listing or post-final-designation. We define the two treatment dummies to be mutually exclusive, meaning that post-listing-proposal is equal to one after the listing proposal but is equal to zero *after* the final listing or final designation.

In the Table 2, we focus on three main comparisons. First, we estimate the average post-treatment effects for properties within the critical habitats, relative to all properties that are outside of the critical habitats (columns 1 and 4), up to 10 km in each direction. We find that residential properties inside the critical habitats sell for 11.6% more after the listing proposal, and 18.5% more after the final designation (column 1). Despite the larger sample size, we recover a noisy zero estimate for the effect of the final designation on vacant lands, and an imprecise appreciation following the listing proposal.

We repeat a similar comparison for species habitats (column 2 and 5), comparing properties inside the species habitat to those outside of it. Residential properties see no meaningful change, on average, in their sale prices. In fact, we can reject price changes that are larger than three percent. Vacant lands imprecisely decline in price by 13.8% following the final listing, while they imprecisely increase by 8.3% after the listing proposal.

The third comparison focuses again on critical habitats, but compares them only to properties that are outside the critical habitat, yet within the species habitat. We use this comparison to evaluate whether the designation of critical habitats have a marginal effect, in addition to the effect of the statutory protections from the listing itself, which apply uniformly throughout the species habitat. For both residential properties and vacant lands, we fail to reject a null effect of a final designation relative to the listing. Inside the critical habitats, residential properties imprecisely appreciate after the listing and designation, while vacant lands imprecisely depreciate by 32.3% after the final designation.

Overall, the results in Table 2 agree with the results reported in Figures 4-8. The price of residential properties increases inside critical habitats, relative to outside, following the final designation, while vacant lands imprecisely depreciate in value. Across the border of a species habitat, on average, residential properties and vacant land see very small, if any, changes in price.

In both the critical habitats and species habitats analyses, we estimate an average effect across the US, or the Pacific Southwest. In the Appendix, Figures A3 and A4, we decompose these effects by each species listing or designation for which we have a complete set of transactions inside and outside, both before and after the treatment onset. The estimation results by species reveal considerable heterogeneity across our set of non-aquatic species. For critical habitats, the kernel densities, weighted by the proportion of transactions inside the habitat, sold after the final designation, as shown in panels b and d of Figure A3, echo our earlier results: residential properties by and large sell for higher prices, while vacant lands sell for lower prices, yet in both cases the share of transactions inside is small, leading to low precision in the results by species as well as the average treatment effect estimation. In the case of species habitats, the kernel densities in Figure A4 recover distributions centered around zero, yet many listings result in precise positive or negative price effects for both residential properties or vacant lands. Further research is needed to clarify which local land market features best explain these findings.

We further decompose the average treatment effect results for species habitat by estimating average treatment effects conditional on the listing history length. In Figure A5, we report the results from a single regression where we interact the post-final-listing dummy with dummies for the number of previous species habitat listings, for either residential properties or vacant lands. We find that for residential properties, the first listing, that is, going from no previous listings to the first enactment of statutory protection, matters the most. The first listing event increases sale price by close to ten percent inside the species habitat, relative to outside. Subsequent listings have smaller and imprecise impacts on the sale price. In the case of vacant lands, the imprecision in the estimated effects complicates the interpretation.

6 The Impacts of the Endangered Species Act on Construction Activity

6.1 Estimating Effects Using County-Level Data

Our land market analysis at the parcel level focuses on the timing of treatment, and the distance from the border that defines treatment. However, we can also consider broader effects on larger areas treated by the statutory protections. To study broader effects on housing supply, we use aggregated data on construction activity at the level of the county. Our main outcome of interest is the number of unit or building construction permits, or the Army Corp of Engineers permits in year y, for county c, in state s, in FWS region r.

We use either the level of total permits, or transform them using the inverse-hyperbolic-sine (Burbidge et al. 1988; Bellemare and Wichman 2020).[18] Using the data on permits and habitats to which ESA statutory protection apply, we estimate the following TWFE specification:

$$\text{Permits}_{csry} = \beta(\text{Habitat Area})_{csry} + \phi_c + \rho_{yr} + \varepsilon_{csry} \tag{4}$$

We measure habitat area in three different ways: total area, total unique area, and share of area. When counting the total area, we allow double counting of the same plot of land for every species for which it is protected. Thus, if the same parcel is protected for an owl and a lizard, we will count it twice. This allows us to account for potential increases in treatment intensity as more species are listed in the county, even if previous protected habitats extend throughout large parts of the county. Conversely, unique total area avoids double counting and only accounts for expansions that extend protections to new areas. To better reflect that counties vary in their total size, we also calculate the share of uniquely protected area (calculated as the percentage of land cover that is protected). We produce estimates using these variables either in levels or in logs.

To control for baseline differences, we include county fixed effects, ϕ_c. We control flexibly for time using either census region by year fixed effects, ρ_{yr}, or state-by-year fixed effects. We cluster the standard errors at the county level.

6.2 Results for Construction Permit Outcomes

Land-use restrictions from ESA regulations have been hypothesized to result in a reduced rate of housing development in a given locality. In theory, housing supply could decline, and housing prices could increase if the rate of new construction slows down because complying

[18] We apply this transformation in order to avoid dropping observations with zeros.

with ESA regulations is costly to real-estate developers. However, we do not find any evidence supporting the theory that additional ESA protections result in fewer construction permits issued either by local jurisdictions or by the US Army Corps of Engineers (ACE).

To measure the intensity of ESA land-use restrictions in a county, we use two separate variables that capture the amount of land under statutory protections. As we discuss in greater detail in Section 4, we measure ESA regulatory intensity by either using the share of land, or the total non-unique acres that are under statutory protections. We use a TWFE specification in Equation (4) to examine how the number of construction permits changes with increases in ESA regulatory intensity as defined by the above-described measures. Statutory protections apply throughout the species and critical habitats; we estimate the effect using both types of habitats.

For both species habitats and critical habitats, using our two measures of ESA intensity in a county-year pair, we recover point estimates and standard errors that are small in magnitude. These allow us to reject the idea that the ESA results in large reductions in land development. We acknowledge that there could be effects we cannot uncover at a small local scale due the county level aggregation of the data. In Tables 3 and 4, we summarize the results in two panels for final species listings and final critical habitat designations separately. We report results for the number of permitted building units, the number of Corps permits, and the share of Corps permits that were issued with special conditions or were denied.

For final listings, results in Table 3 Panel A, show that for a one percent increase in the total area under ESA statutory protections, there is a one-tenth of a percent reduction in the number of construction permits (column 1). We use the total area, which double counts overlapping habitats because we interpret this measure as the protection intensity, and a proxy for the probability of there being a binding constraint on land development. Using the share of unique area, which does not double count overlapping habitats, we find a one percentage-point increase imprecisely lowers construction permits by two-tenths of a percent (column 2). In Panel B, we repeat the estimation using the amount of land designated as critical habitats. We estimate small, imprecise, and positive coefficients (columns 1 and 2), which is not consistent with a negative impact on development.

Anecdotal evidence suggests there was a regime shift that relaxed the degree of ESA enforcement following the Clinton Administration, which ended in 2001.[19] We test for this potential differential degree of enforcement by either including interactions for the two time periods, or by estimating the results using two sub samples, pre-2001 and post-2001. For listings, the effect for total area does not change (Panel A, column 3). The effect for the area share is negative during the 1990 to 2000 period, and positive during the 2001 to 2019 period, yet remains imprecisely estimated (Panel A, column 4). When splitting the sample, the negative effect of total area is only present in the 1990 to 2000 period (Panel A, columns 5 and 7), while the sign of the coefficients for the area share flips signs relative to the interacted regression (Panel A, columns 6 and 8). For designations, the interacted regressions do not result in meaningfully different estimates (Panel B, column 3 and 4). When splitting the sample, increases in designated area precisely and meaningfully lower construction permits in the 1990 to 2000 period (Panel B, columns 5 and 6). However, there are only 25 critical habitat designations that take place during that time period, making it hard to generalize these results. Additionally, while the effect of the area share is one to two orders of magnitude larger than the other reported effects, it is important to remember that the mean and standard deviations values of the designated area share in the full sample are 0.007 and 0.07, respectively (see Table 1, Panel D.). This means that the average county in our samples sees a 0.013% reduction in construction permits issued by the jurisdiction, during the 1990 to 2000 period.

We further investigate the potential channel of permitting by evaluating whether the Corps awards fewer permits, or issues them with more restricting conditions. In Table 4, we

[19] In an interview to WUSF, journalist Jimmy Tobias commented that "...when I speak to Fish and Wildlife Service people, they often look back on the [...] Clinton era, when Molly Beatty was the director of the Fish and Wildlife Service, as a really high point for the agency. But since then, there seems to be a trend where it has become ever weaker." Source: https://wusfnews.wusf.usf.edu/environment/2021-02-05/lack-of-enforcement-threatens-the-endangered-species-act. Accessed 04/22/2021.

report a similar estimation to that in Table 3. For both listings and designations, we fail to reject very small effects on the number of permit applications (Panels A and B, columns 1 and 2). However, we do find a meaningful effect on the composition of permits issued with special conditions, but that effect is driven mostly by recent permitting in the 2001 to 2019 period (Panels A and B, column 4). The share denied permits declined with more listed acres, and does not precisely change with designated acres, again, not consistent with the idea of negative impacts on land development from ESA regulations (Panels A and B, columns 5 and 6). Overall, we interpret the results on construction and Corps permits as there being very small, if any, effects of listings and designations on *the amount of* land development activity throughout recent decades.

The number of permits, issued by the Corps, is only one dimension through which we can evaluate the impacts of the ESA. As we show in Figure 9, there is a secular downward trend in the total number of permits issued by the Corps. The composition of Corps decisions has also shifted towards the majority of permits issued since 2008 to be awarded with special conditions, a trend that started with the 2002 approval of the nationwide Corps permits.[20]

The action that the Corps takes in its type of approval, or denial, of a permit, and its issuance under either a Letter of Permission or Standard Permit are also important features of how permitting by the Corps might change as a result of additional ESA protections. Permits issued with special conditions might involve costly compliance costs. Standard Permits result in longer, well above 120 days, approval processes relative to a Letter of Permission. In Figure 10, we plot binned values for the percent of permits issued with special conditions, or the percent of permits issued as Standard Permits, as a function of either total or unique species habitats, in log points. All four panels suggest a convex relationship between listed acres and the share of permits that are likely to reflect higher development costs, and longer delays to developers. In other words, while the number of Corps permits does not appear

[20] As part of the 2002 nationwide permits, which updated the 1996 nationwide permits, the Corps made modifications to nine existing permit types, and to six general conditions, while adding one new general condition (Engineers Corps 2002).

to meaningfully increase due to additional listed or designated acres, the composition of permits appears to shift. Explicitly, the composition leans more towards private landowners and developers experiencing greater regulatory stringency due to higher levels of protected acres under the ESA.

6.3 Evidence for Potential Delays Using Habitat Conservation Plans

The number of construction permits and permits issued by the ACE provide a proxy to measure construction activity, and how ESA regulations might disrupt it. Our analysis of those permits did not reveal a lower number, reflecting a null, on average, result on the magnitude of construction activity. However, 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 land owner seeks to develop their land that is considered a habitat to a listed species, their project is likely to go under review by the FWS (see Section 2 regarding the federal nexus). In some case, the FWS might determine that the land developer needs to obtain an incidental taking permit, which establishes the steps the land owner needs to take to reduce the potential damage that might occur to the species' habitat during development. The process to obtain such a permit requires the development of an HCP.

In other cases, land owners might preemptively develop an HCP even before a species is listed. If their HCP gets approved by the FWS, then they receive a "no surprises assurance." This means that if the species does become listed during the process of the land development, the landowner will not need to develop a new plan or undertake any additional precautionary steps that were not already outlined in the approved HCP.

Landowners have referred to HCPs as "burdensome" (Murray 1997), costly to develop, especially for small landowners (Paulich), and have blamed the FWS as 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 11, as well as correlations in Table 5.

On average, an HCP takes about five years to complete. While this is a long period of time, this simple mean hides important heterogeneity. Many HCPs take more than twice that time to complete their development. In Figure 11a, we show that the distribution in years between HCPs for all land-uses and construction projects is similar. Focusing on the HCPs for construction projects, we find that projects that cover longer areas, request a longer duration for their incidental taking permit, and were initiated before 2001, take considerably longer. For example, projects above the median level of land covered or permit duration rarely get approved under four years, and on average experience two three years longer planning periods (panels b and c). We document small, if any, differences in approval periods between animals and plants, aquatic and non-aquatic species, species listed as endangered relative to threatened, or species that ever receive a critical habitat designation. We summarize these difference in Table 5, in both levels and logs.

7 Conclusions

Hundreds of species have been listed under the Endangered Species Act (ESA), and its regulations have placed millions of acres of land under statutory protections. In this paper, we analyze the impacts of the ESA on land markets and housing supply at a nationwide scale, for over four, out of the five, decades of the Act's existence. We find economically meaningful effects that vary by the type of land-use, timing of enactment, and distance to the border of the protected area. Our analysis extends previous work that focused on limited regional and temporal scales, and contributes both to the specific literature on the ESA, and to the work on land-use restrictions.

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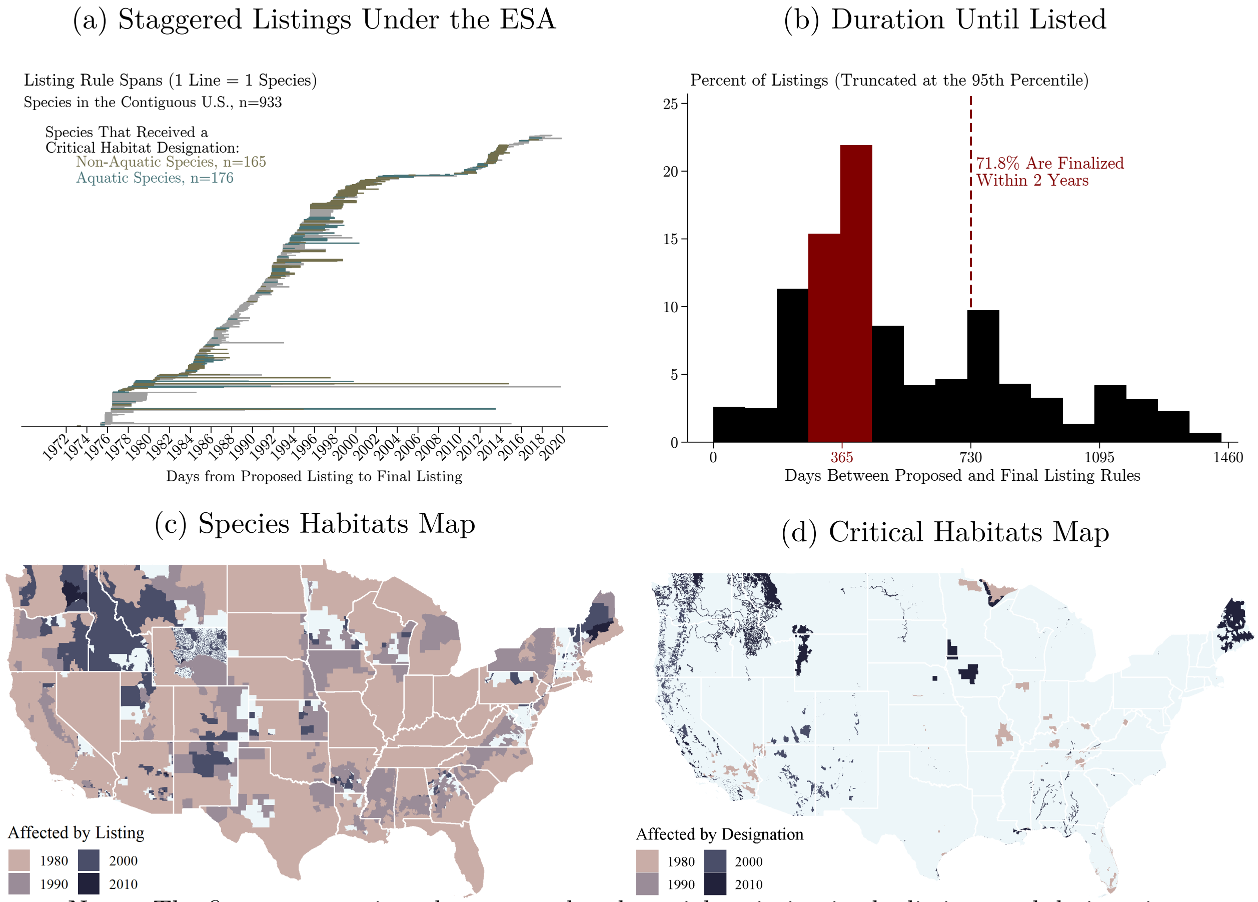
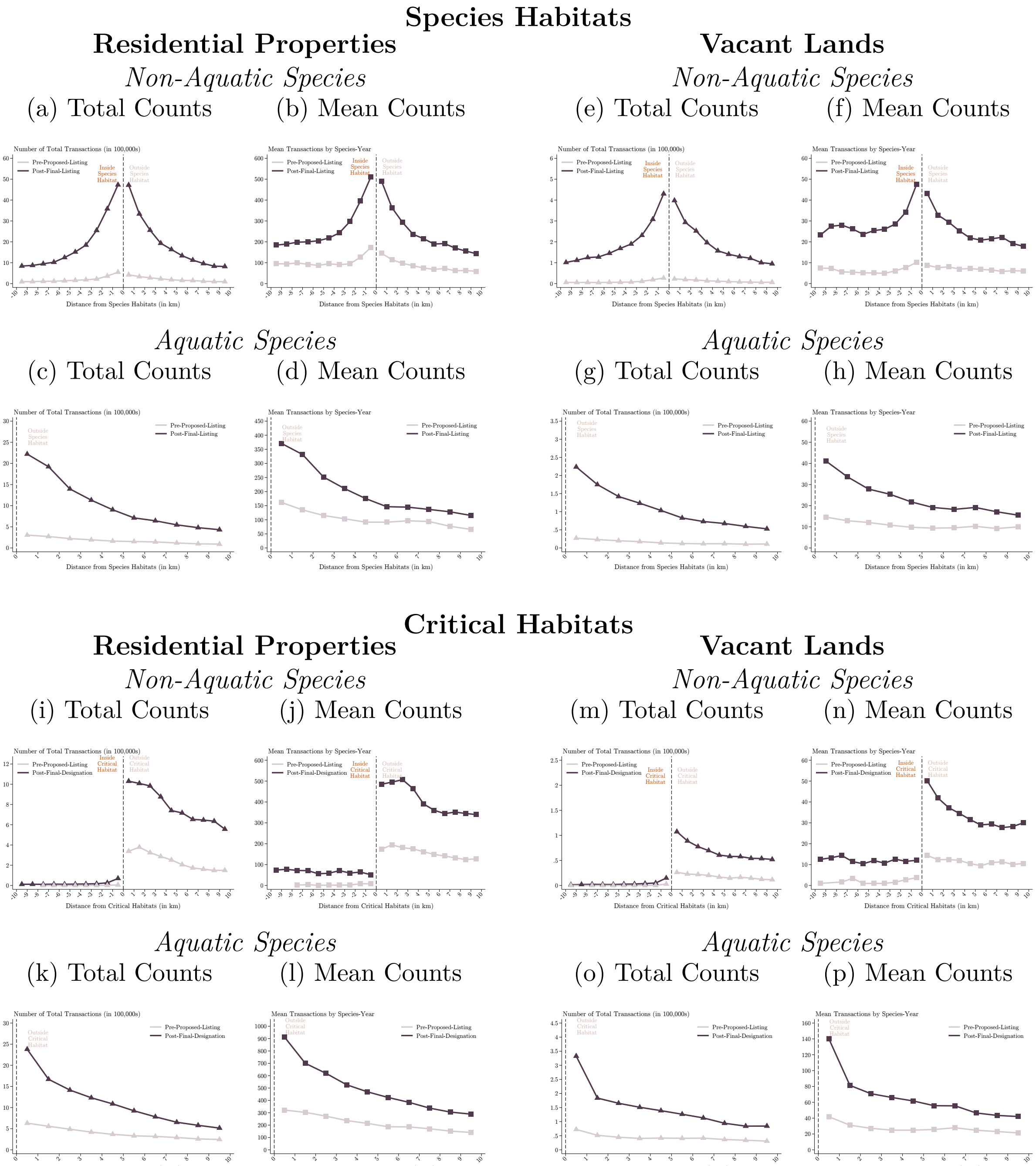
Figure 1: ESA Listings & Designations in the Contiguous US



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 award 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% of a state's land area. (d) Same as (c), only for critical habitats.
Source: Data on the timing of listings and designations from the Fish and Wildlife Service Species Data Explorer and Environmental Conservation Online System.

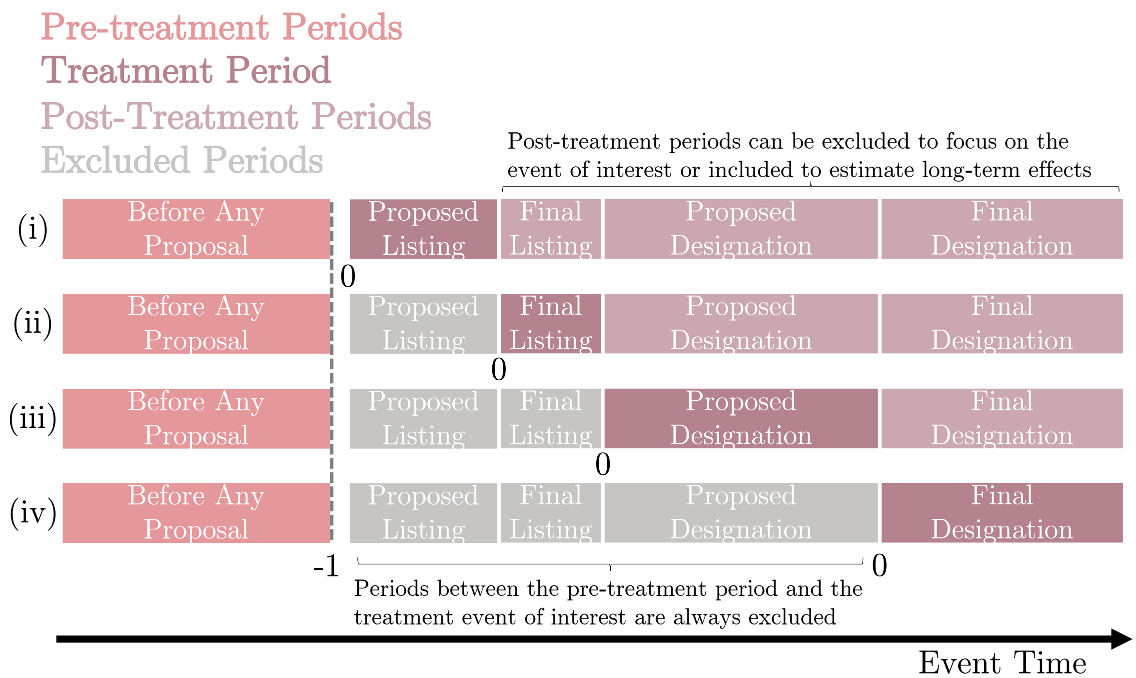
Figure 2: Number of Residential Property Transactions Around Habitat Borders



Notes: The figures summarize the number of transaction around the border of the species and critical habitats, before the listing proposal, and after the final listing (species habitats) or final designation (critical habitats). For residential properties and vacant lands, by aquatic and non-aquatic species, we present both the total counts, as well as counts normalized by the number of species and the number of years of data available for before and after the proposed and final rules. Source: Transactions data from CoreLogic. Habitat borders and listing dates from FWS.

Figure 3: Schematic Research Design for Staggered Treatments

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



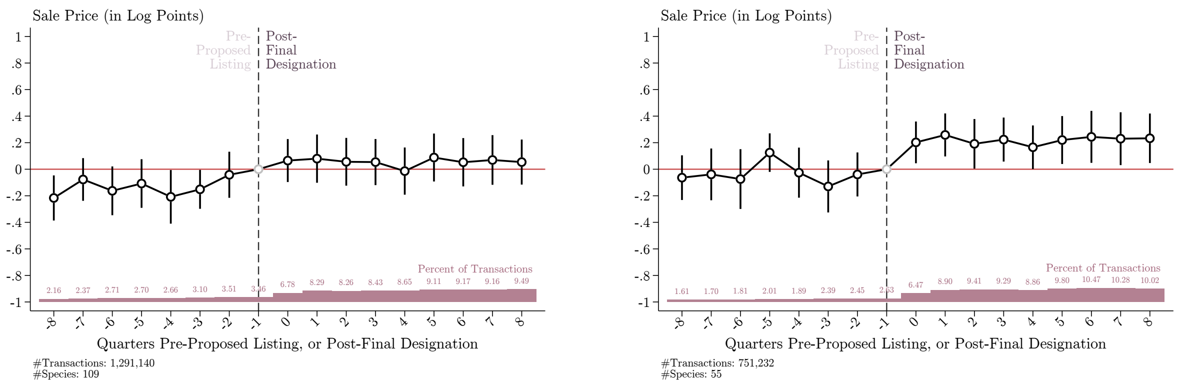
(b) Example: Two Species, Case (ii)

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 time periods as the pre-treatment 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. If there are time periods between the first proposal to list or designate, and the ESA event of interest, we exclude 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 re-center before any proposal (B) and exclude the time periods where the species have a proposed listing status (P).

Figure 4: The Effect of Final Designation on Residential Properties

(a) CONUS   (b) Pacific Southwest

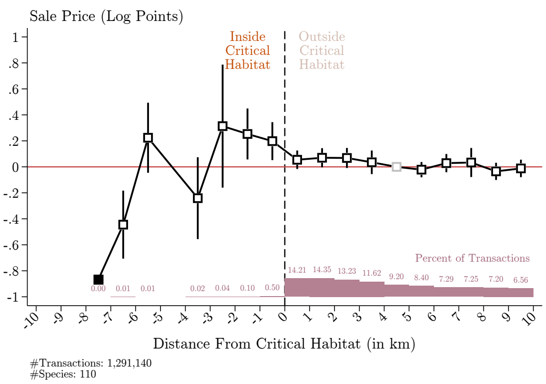


Notes: Regression results from Equation (1). Point estimates and 95% CIs for β_τ (the interaction terms for event-time dummies with the dummy variable for being inside the protected area). The sample includes all properties ten km from the border of a critical habitat, within two years before the proposed listing, and two years after the final designation. Each regression includes ZCTA, species, as well as sample year calendar month by FWS region fixed effects. Standard errors are clustered at the ZCTA level.
Source: See Figure 2

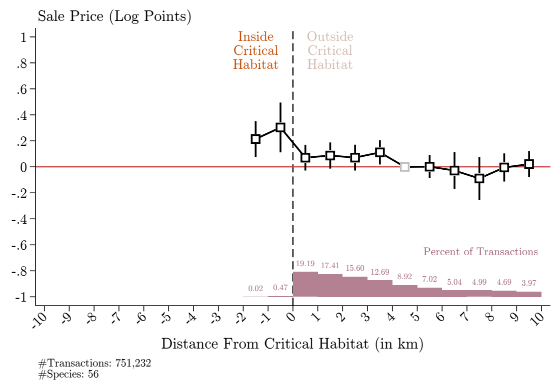
Figure 5: Final Designation Effects Around the Border on Residential Properties

Transactions in Four-Year Time Window

(a) CONUS

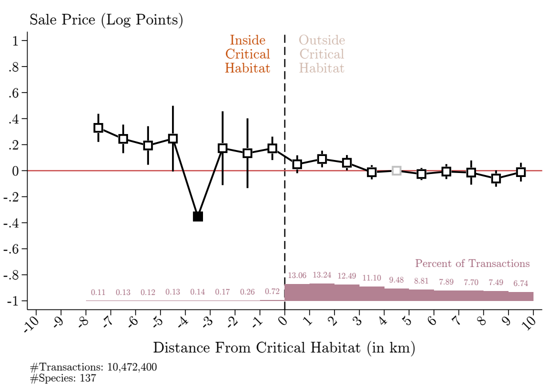


(b) Pacific Southwest

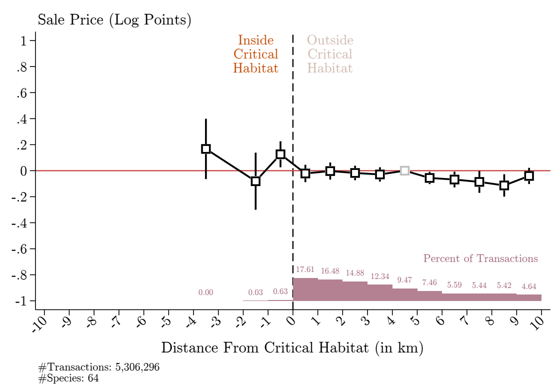


All Transactions

(c) CONUS



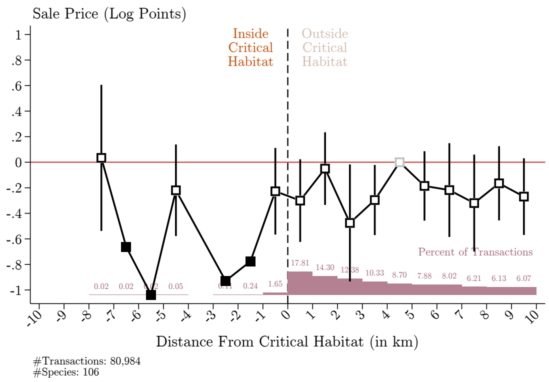
(d) Pacific Southwest



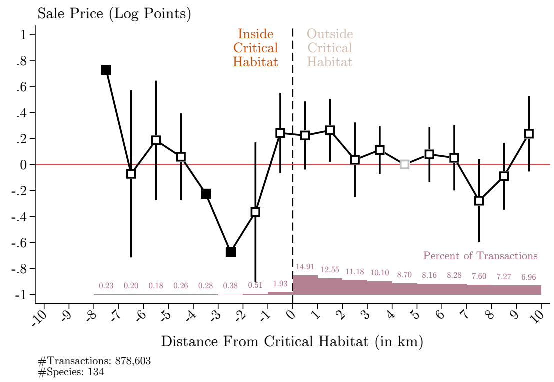
Notes: Regression results from Equation (2). Point estimates and 95% CIs for δ_k (the interaction terms for distance-bin dummies with the dummy variable for being post-treatment). In the case of imprecisely estimated coefficients, we exclude their 95% CIs if they extend above or below positive or negative one, respectively (filled squares). The sample includes all properties ten km from the border of a critical habitat. Sample includes all properties ten km from the border of a critical habitat, within two years before the proposed listing, and two years after the final designation (panels (a) and (b)), or all transactions except those between the proposed listing and final designation (panels (c) and (d)). Each regression includes ZCTA, species, as well as sample year calendar month by FWS region fixed effects. Standard errors are clustered at the ZCTA level.
Source: See Figure 2.

Figure 6: Final Designation Effects Around the Border on Vacant Lands in CONUS

(a) Transactions in Four-Year Time Window



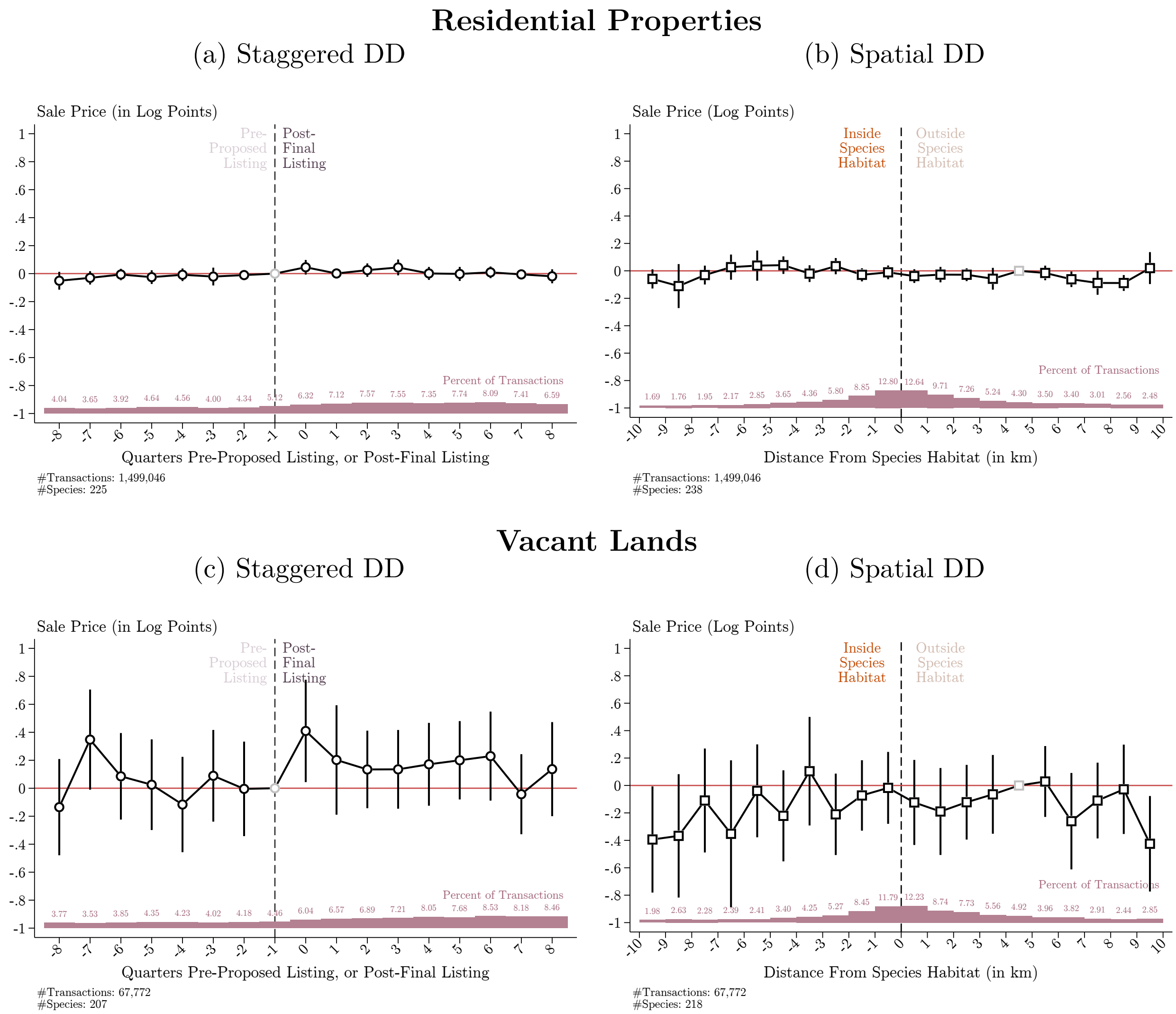
(b) All Transactions



Notes: Regression results from Equation (2). Point estimates and 95% CIs for δ_k (the interaction terms for distance-bin dummies with the dummy variable for being post-treatment). In the case of imprecisely estimated coefficients, we exclude their 95% CIs if they extend above or below positive or negative one, respectively (filled squares). The sample includes all properties in the contiguous US ten km from the border of a critical habitat, within two years before the proposed listing, and two years after the final designation (a), or all transactions except those between the proposed listing and final designation (b). Each regression includes ZCTA, species, as well as sample year calendar month by FWS region fixed effects. Standard errors are clustered at the ZCTA level

Source: See Figure 2.

Figure 7: Final Listing Effects on Residential Properties & Vacant Lands in CONUS

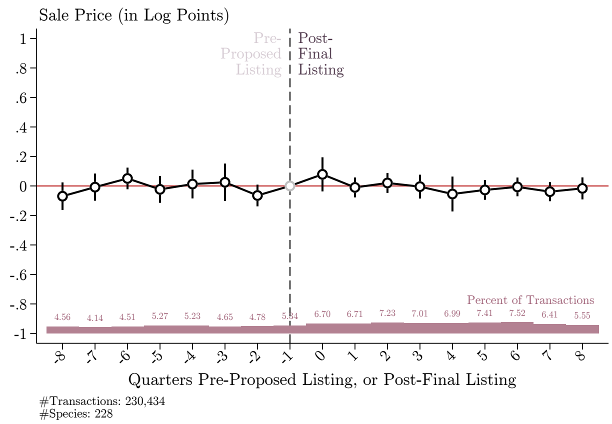


Notes: Regression results from Equations (1) and (2). Point estimates and 95% CIs for β_τ (the interaction terms for event-time dummies with the dummy variable for being inside the protected area), as well as δ_k (the interaction terms for distance-bin dummies with the dummy variable for being post-treatment), respectively. The sample includes all properties ten km from the border of a species habitat, within two years before the proposed listing, and two years after the final listing. Each regression includes ZCTA, species, listing history (see main text), as well as sample year calendar month by FWS region fixed effects. Standard errors are clustered at the ZCTA level.
Source: See Figure 2

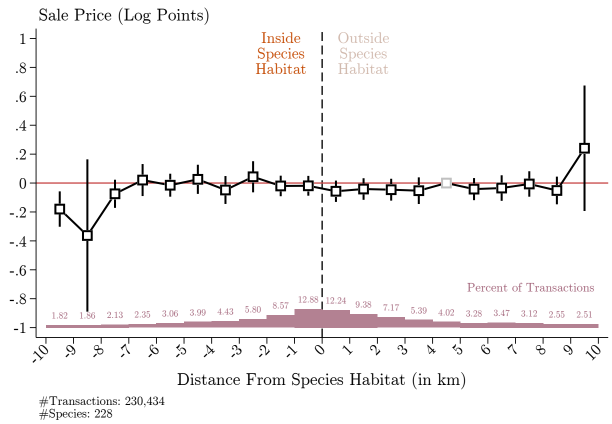
Figure 8: Final Listing Effects on Residential Properties in CONUS Using Repeated Sales

Repeated Sales Sample Without Parcel Fixed Effects

(a) Staggered DD

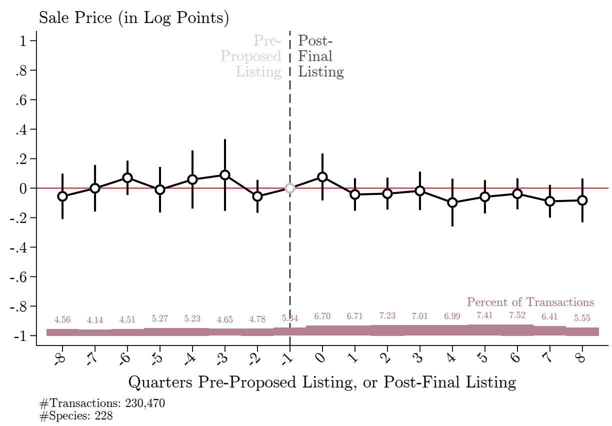


(b) Spatial DD

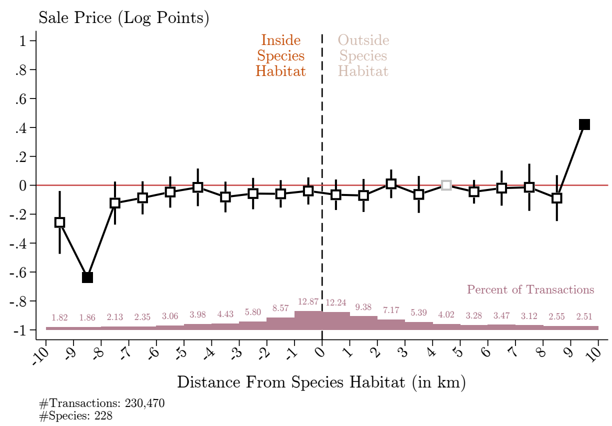


Repeated Sales Sample With Parcel Fixed Effects

(c) Staggered DD



(d) Spatial DD

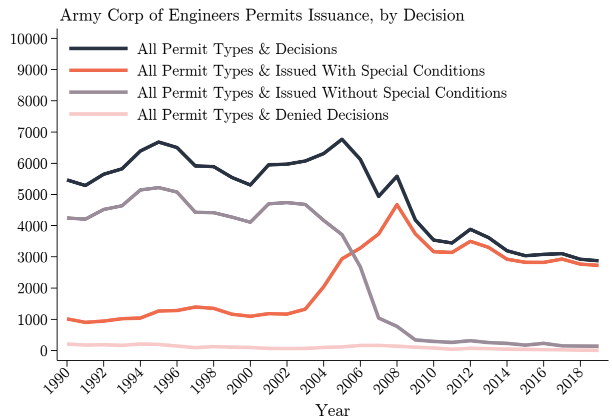


Notes: Regression results from Equations (1) and (2). Point estimates and 95% CIs for β_τ (the interaction terms for event-time dummies with the dummy variable for being inside the protected area), as well as δ_k (the interaction terms for distance-bin dummies with the dummy variable for being post-treatment), respectively. The sample includes all properties ten km from the border of a species habitat, within two years before the proposed listing, and two years after the final listing. Each regression includes parcel fixed effects along with species, listing history (see main text), as well as sample year calendar month by FWS region fixed effects. Standard errors are clustered at the ZCTA level.

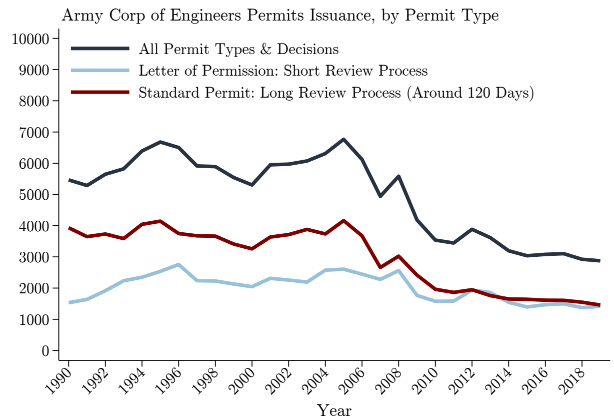
Source: See Figure 2

Figure 9: Secular Trends in Army Corp of Engineers Permits Issuance

(a) By Decision



(b) By Permit Type

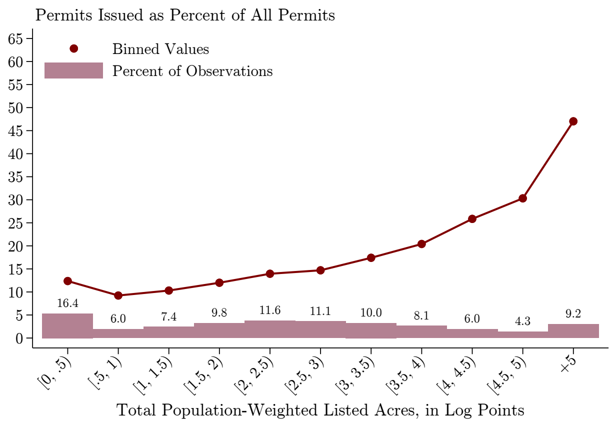


Notes: National level summary on permits issued by the Army Corp of Engineers, by decision type (a), or by the type of permit (b).
Source: Army Corp of Engineers.

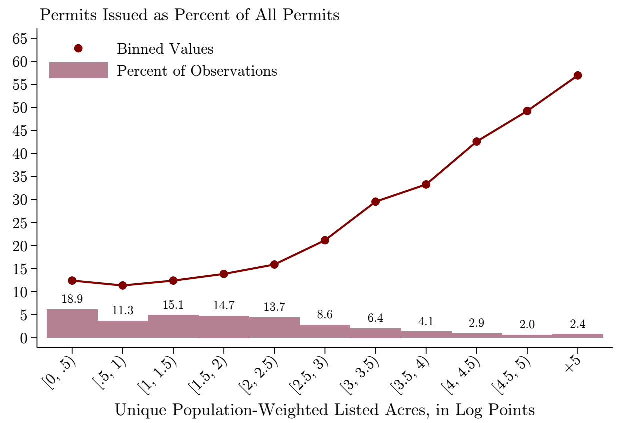
Figure 10: Army Corp of Engineers Permit Issuance & Listed Acres

Percent Issued With Special Conditions

(a) Total Listed Acres

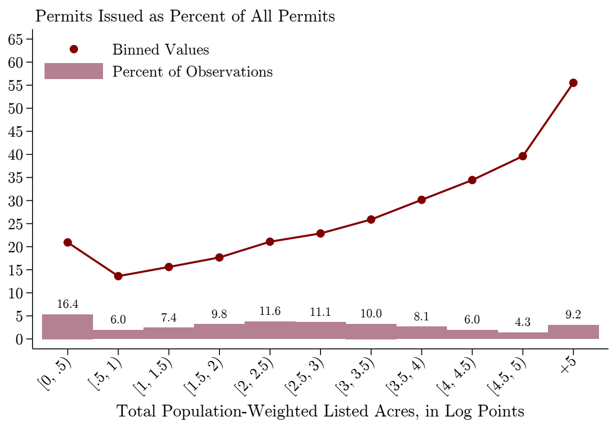


(b) Unique Listed Acres

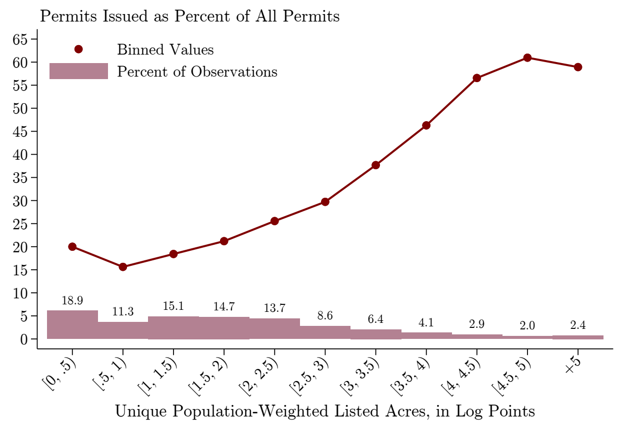


Percent Issued as Standard Permits

(c) Total Listed Acres



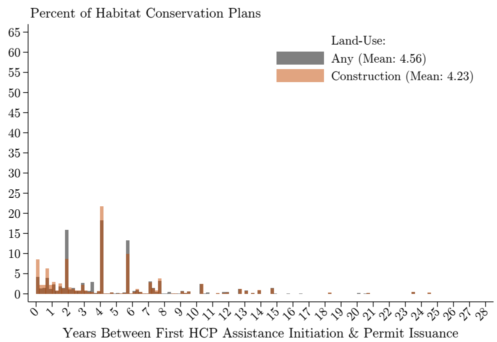
(d) Unique Listed Acres



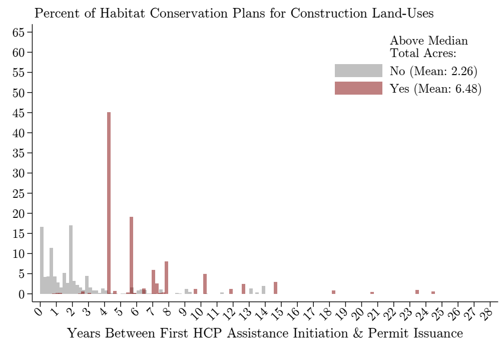
Notes: Data at the county-year level for 2,839 counties, on permits issued by the Army Corp of Engineers (Corps) as a function of either total listed species habitat area, or unique listed area. Total area double counts listed acres to capture potentially growing stringency and binding ESA restrictions. Unique area avoids double counting listed acres. Both area variables are weighted using gridded population data (see appendix for more details), and are transformed using the inverse-hyperbolic-sine function. Permits are measured as the percent, relative to all issued permits, of permits issued with special conditions (the action taken by the Corps), or as permits issued as standard permits (the permit type issued by the Corps, which involves a longer processing period of approximately 120 days).
Source: Army Corp of Engineers. Listed acres data from FWS. Gridded population data from NASA's SEDAC US Census Grids.

Figure 11: Potential Delays From Habitat Conservation Plan Approvals

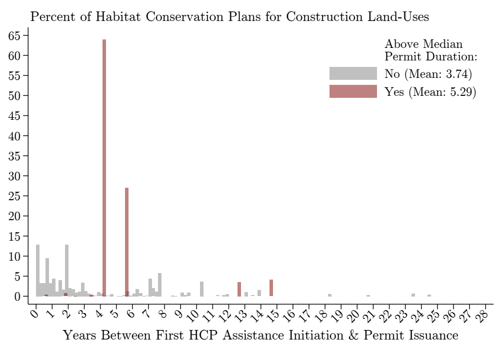
(a) Land-Use



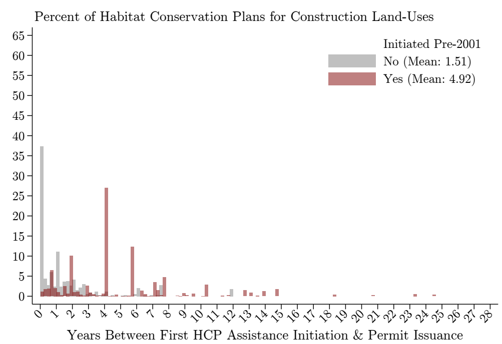
(b) Total Acres



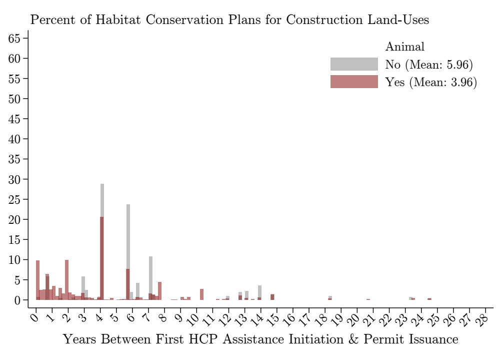
(c) Permit Duration



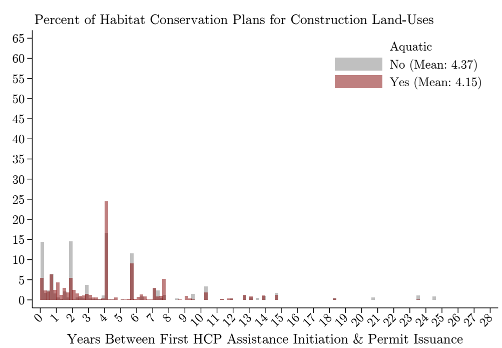
(d) Initiated Pre-2001



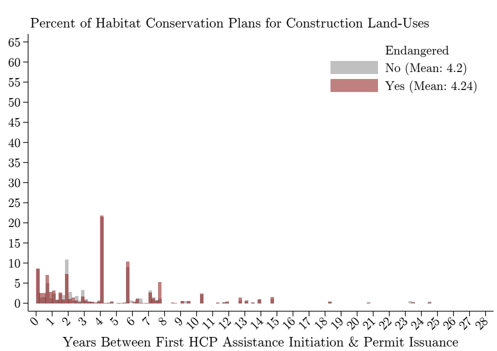
(e) Animals VS. Plants



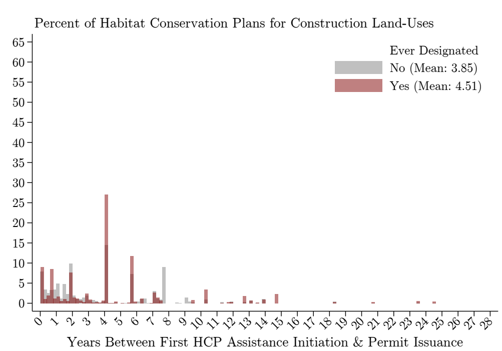
(f) Aquatic VS. Non-Aquatic



(g) Endangered VS. Threatened



(h) Designated Critical Habitats



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

Table 1.
Summary Statistics

Variable	Mean	SD	Min	Max	N
Panel A. Transactions Data (*CoreLogic Tax and Deed History Database)*					
Critical Habitats, Residential Properties					
Sale Price	444,582.4	2.87×10^7	1,001	8.03×10^9	32,594,919
Inside Habitat	0.037	0.2	0	1	32,594,919
Critical Habitats, Vacant Lands					
Sale Price	1,064,124	1.22×10^7	1,001	8.21×10^9	3,343,612
Inside Habitat	0.032	0.18	0	1	3,343,612
Species Habitats, Residential Properties					
Sale Price	451,570.8	2.34×10^7	1,001	1.00×10^{11}	68,940,081
Inside Habitat	0.51	0.49	0	1	68,940,081
Species Habitats, Vacant Lands					
Sale Price	891,952.7	1.12×10^7	1,001	8.21×10^9	6,975,611
Inside Habitat	0.52	0.49	0	1	6,975,611
Panel B. Building Permits Data(*US Census Bureau*)					
Units	436.3	1,517.04	0	54,892	88,911
Building	328.1	1,073.8	0	48,228	88,911
asinh(Units)	4.6	2.4	0	11.6	88,911
asinh(Building)	4.4	2.3	0	11.5	88,911
Panel C. Army Corp of Engineers Permits Data					
Application count	1.75	6.94	0	285	85,170
asinh(Application)	0.59	0.97	0	6.35	85,170
Share issued w/ cond	18.4	37.6	0	100.0	85,170
Share denied	0.8	7.1	0	100.0	85,170
Panel D. Habitat Area, in Million Acres (Pop. Weighted) (*U.S. FWS*)					
SH Share	0.83	0.37	0	1	92,366
Total SH	18.5	108.4	0	3,919.6	92,366
Unique SH	3.7	14.2	0	489.02	92,366
CH Share	0.007	0.07	0	0.99	92,366
Total CH	0.03	0.3	0	9.1	92,366
Unique CH	0.03	0.3	0	9.1	92,366
Panel E. Habitat Conservation Plans (*US FWS*)					
HCP Timeline (Years)	5.02	4.55	0	24.45	75,851

Notes: Summary statistics at the transaction level (Panel A), the county level (Panels B, C and D) and the plan level (Panel E). FWS, SH, and CH abbreviate Fish and Wildlife Service, species habitats, and critical habitats, respectively.

Table 2
Average Treatment Effects for Species Habitats (SH) & Critical Habitats (CH)

	Residential Properties			Vacant Lands		
	CH	SH	M. CH	CH	SH	M. CH
	(1)	(2)	(3)	(4)	(5)	(6)
Inside×FD	0.174***		0.174	-0.013		-0.390
	(0.043)		(0.156)	(0.146)		(0.239)
Inside×LP	0.108*	-0.009	0.114	0.173	-0.129	0.023
	(0.063)	(0.021)	(0.140)	(0.194)	(0.090)	(0.206)
Inside×FL		0.002			0.082	
		(0.019)			(0.081)	
Inside	0.075*	0.015	-0.045	0.059	0.132***	0.435**
	(0.040)	(0.014)	(0.134)	(0.130)	(0.051)	(0.216)
FD	-0.010		-0.049	0.196**		0.114
	(0.014)		(0.071)	(0.082)		(0.198)
LP	-0.019	-0.029*	0.023	0.057	0.032	-0.140
	(0.011)	(0.015)	(0.024)	(0.092)	(0.068)	(0.111)
FL		0.005			-0.023	
		(0.014)			(0.056)	
R^2	0.549	0.504	0.428	0.456	0.447	0.464
N	13,612,955	43,101,584	2,808,738	1,049,577	4,053,248	410,724
Clusters	3,358	18,041	2,350	2,952	14,673	1,729

Notes: Estimation results from Equation (3). We estimate the average treatment effect of listing propsoals (LP), final listings (FL), and the final designation (FD). The dummy for post-listing-proposal is equal to one for time periods after the listing proposal and up to the final listing or final designation dates. Each Sample includes all the transactions in the data. We estimate the average treatment effect on properties inside the critical habitat (columns 1, 3, 4, and 6), or inside the species habitat (column 2 and 5), after the listing proposal, and after the final designation (columns 1, 3, 4, and 6) or final listing (columns 2 and 5), relative to the properties outside the protected habitat before the listing proposal. In columns 4 and 6, we repeat the estimation in columns 1 and 4, but restrict the sample to include only properties that are within the species habitats of the designated species (critical habitats are subset of species habitats). The comparison of properties within the critical habitat only to those outside the critical habitat but within the species habiat, allows us to estimate the marginal treatment effect of critical habiat designation that is in addition to the statutory protection applied uniformly acorss the species habitat. Each regression includes ZCTA, species, as well as sample year calendar month by FWS region fixed effects. Regressions for species habitat also include a listing history group fixed effect (see main text for details). Standard errors are clustered at the ZCTA level.
* p<0.1, ** p<0.05, *** p<0.01.

Table 3.
Logged Construction Permits For Total Units, 1990 - 2019

Sample Years:	1990 - 2019				1990 - 2000		2001 - 2019	
[N_{Listings} - $N_{\text{Designations}}$]	[553 - 267]				[387 - 25]		[166 - 242]	
Panel A. Species Habitats Effects (Listings)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IHS(Total Area)	-0.09***				-0.08***		-0.03	
	(0.02)				(0.02)		(0.02)	
Area Share		-0.02				0.05		-0.04
		(0.04)				(0.05)		(0.05)
IHS(Total Area)×[1990, 2000]			-0.09***					
			(0.02)					
IHS(Total Area)×[2001, 2019]			-0.09***					
			(0.02)					
Area Share×[1990, 2000]				-0.05				
				(0.04)				
Area Share×[2001, 2019]				0.05				
				(0.04)				
R^2	0.90	0.90	0.90	0.90	0.94	0.94	0.92	0.92
Panel B. Critical Habitats Effects (Designations)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IHS(Total Area)	0.03				-0.17***		0.03	
	(0.05)				(0.05)		(0.04)	
Area Share		0.16				-1.85**		0.11
		(0.12)				(0.87)		(0.12)
IHS(Total Area)×[1990, 2000]			-0.01					
			(0.08)					
IHS(Total Area)×[2001, 2019]			0.03					
			(0.04)					
Area Share×[1990, 2000]				0.20				
				(0.20)				
Area Share×[2001, 2019]				0.16				
				(0.12)				
R^2	0.90	0.90	0.90	0.90	0.94	0.94	0.92	0.92
County FEs	X	X	X	X	X	X	X	X
Region-Year FEs	X	X	X	X	X	X	X	X
N	88,796	88,796	88,796	88,796	32,512	32,512	56,284	56,284
Clusters	3,009	3,009	3,009	3,009	2,975	2,975	3,002	3,002

Notes: Estimation results for the total number of constuction permits for all units, as a function of habitat area receiving statutory protection under the ESA. We transform the number of construction permits, and the total number of acres using the inverse-hyperbolic-sine function. Habitat acres are population weighted. Standard errors are clustered at the county level. * p<0.1, ** p<0.05, *** p<0.01.

Table 4.
Logged Army Corps of Engineers Permits, 1990-2019

	Number of Applications		Share Issued w/ Conditions		Share Denied		Share of Standard Permit	
Panel A. Species Habitats Effects (Listings, N=553)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IHS(Total Area)	-0.05***		0.77		-0.35***		-2.69***	
	(0.01)		(0.88)		(0.13)		(0.70)	
IHS(Total Area) × [1990,2000]		-0.05***		-3.42***		-0.32***		-2.20***
		(0.02)		(0.85)		(0.14)		(0.74)
IHS(Total Area) × [2001,2019]		-0.05***		1.65***		-0.35***		-2.80***
		(0.01)		(0.80)		(0.13)		(0.70)
R^2	0.64	0.64	0.33	0.34	0.08	0.08	0.27	0.27
Panel B. Critical Habitats Effects (Designations, N=267)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IHS(Total Area)	0.01		1.18**		-0.03		-0.13	
	(0.01)		(0.47)		(0.06)		(0.36)	
IHS(Total Area) × [1990,2000]		-0.01		-1.45***		-0.12		-0.44
		(0.01)		(0.61)		(0.08)		(0.41)
IHS(Total Area) × [2001,2019]		0.01		1.38***		-0.03		-0.10
		(0.01)		(0.48)		(0.06)		(0.36)
R^2	0.64	0.64	0.33	0.34	0.08	0.08	0.27	0.27
County FEs	X	X	X	X	X	X	X	X
Region-Year FEs	X	X	X	X	X	X	X	X
N	85,170	85,170	85,170	85,170	85,170	85,170	85,170	85,170
Clusters	2,839	2,839	2,839	2,839	2,839	2,839	2,839	2,839

Notes: Estimation results for the number of US ACE individual permits of all types, and the share of permits issued with special condition and the share of permits denied, as a function of habitat area receiving statutory protection under the ESA. We transform the number of permits, and the total number of acres using the inverse-hyperbolic-sine function. Habitat acres are population weighted. Standard errors are clustered at the county level. * p<0.1, ** p<0.05, *** p<0.01.

Table 5.
Number of Years between First Assistance and Permit Decision, 1990-2019

	Levels (Mean = 5.02 years)					Logs				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Pre-Designation	0.77**					0.17***				
	(0.32)					(0.06)				
Ever-Designated		0.17**					0.01			
		(0.08)					(0.03)			
Not-Listed			0.55*					0.10		
			(0.32)					(0.07)		
Animal				-0.35**					-0.11***	
				(0.14)					(0.03)	
[1990, 2000]					-2.18***					-0.42*
					(0.62)					(0.21)
R^2	0.766	0.763	0.762	0.763	0.763	0.736	0.734	0.734	0.735	0.734
FWS-Region-Year FEs	X	X	X	X	X	X	X	X	X	X
Land-Use FEs	X	X	X	X	X	X	X	X	X	X
N	7,791	7,791	7,791	7,791	7,791	7,791	7,791	7,791	7,791	7,791
Clusters	37	37	37	37	37	37	37	37	37	37

Notes: Estimation results for the number of years between the first assistance and the permit decision of all approved HCPs, as a function of the dummy for whether the HCP is submitted before the proposed designation date of its species (column (1)), for whether the species has ever been designated (column (2)), for whether the species has ever been listed (column (3)), for whether the species belongs to animal species (column (4)), as well as for whether the HCP is initiated before the end of 2000 (column (5)). Standard errors are clustered at the state level. * p<0.1, ** p<0.05, *** p<0.01.

Appendix

A Additional Results

A.1 Effects of Different Treatment Onsets Before Final Designation

A.2 The Effects of Final Designation & Final Listing on Aquatic Species

In Figure A2 we repeat the spatial DD analysis for critical and species habitats linked to aquatic species. Overall, the price of residential properties is unaffected by the designation or listing of aquatic species. The prices of vacant lands imprecisely drop close to the critical or species habitat border, but the noise in the distance bin that are much further away from the border (beyond five km) make it hard to interpret as a clear effect of the habitat border.

A.3 Effects Estimated Separately by Species

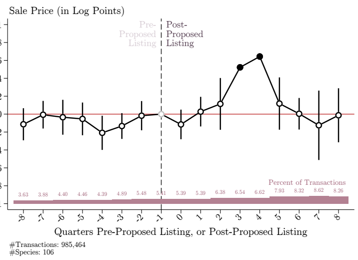
A.4 Effect by Species Listing History Length

Figure A1: Effects of Different Treatment Onsets Before Final Designation

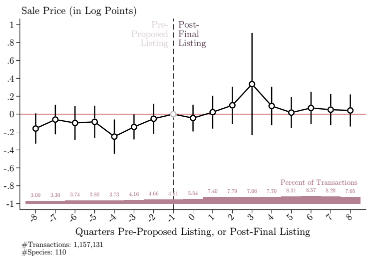
Residential Properties

Staggered DD

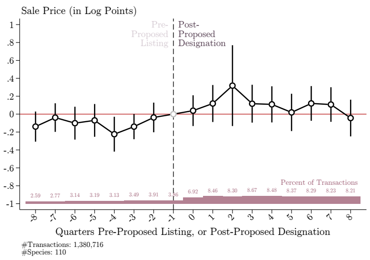
(a) Listing Proposal



(b) Final Listing

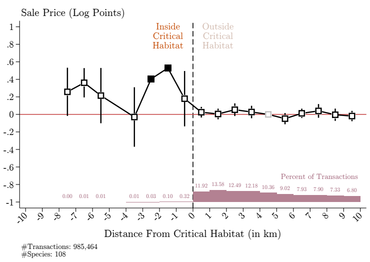


(c) Designation Proposal

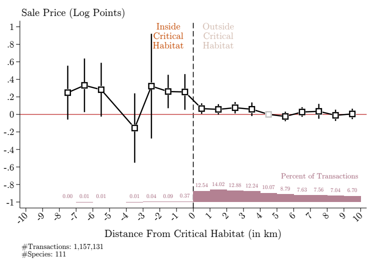


Spatial DD

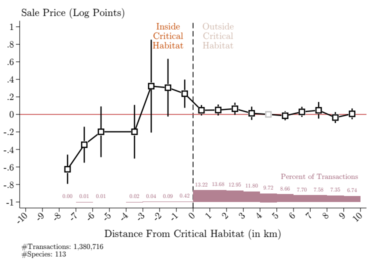
(d) Listing Proposal



(e) Final Listing



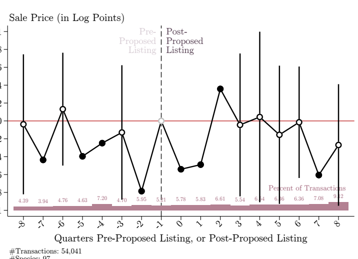
(f) Designation Proposal



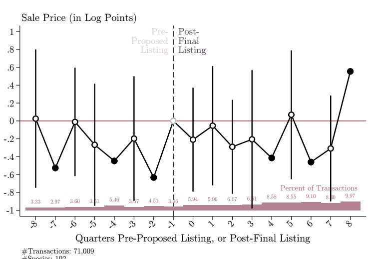
Vacant Lands

Staggered DD

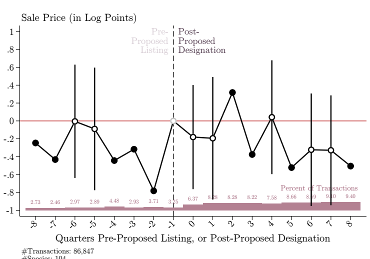
(g) Listing Proposal



(h) Final Listing

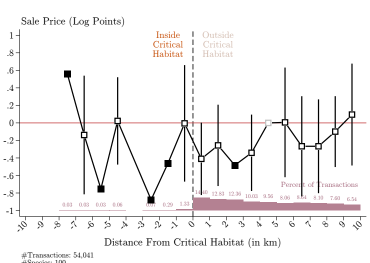


(i) Designation Proposal

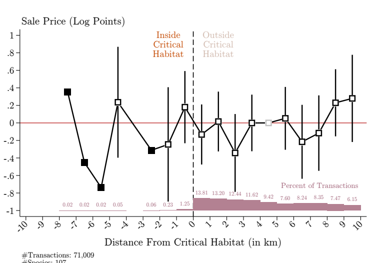


Spatial DD

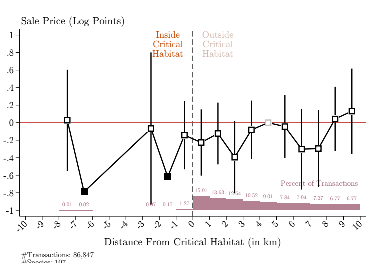
(j) Listing Proposal



(k) Final Listing



(l) Designation Proposal

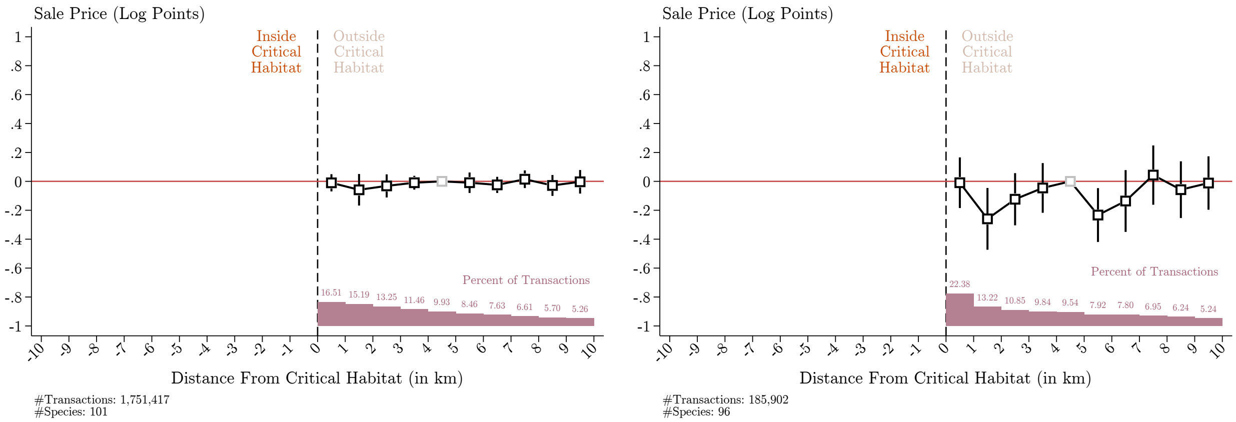


Notes: See Figures and 4 and 5.

Figure A2: The Effect of Final Designation on Aquatic Species

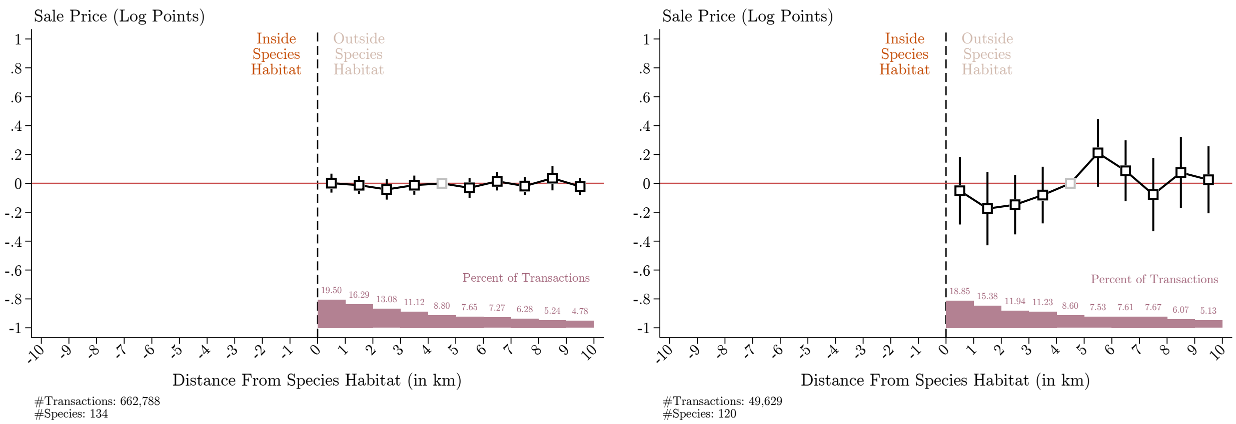
Critical Habitats

(a) Residential Properties (b) Vacant Lands



Species Habitats

(c) Residential Properties (d) Vacant Lands

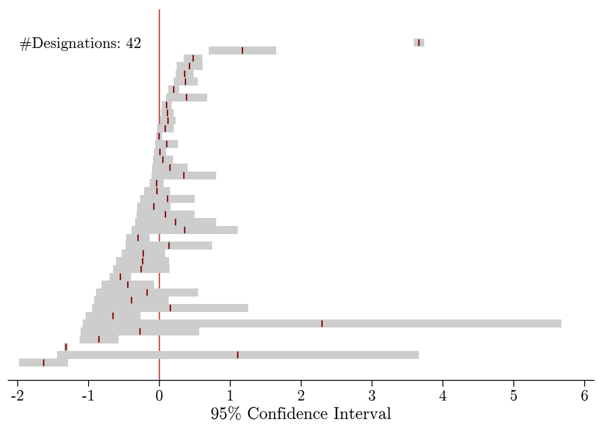


Notes: See Figure 5.

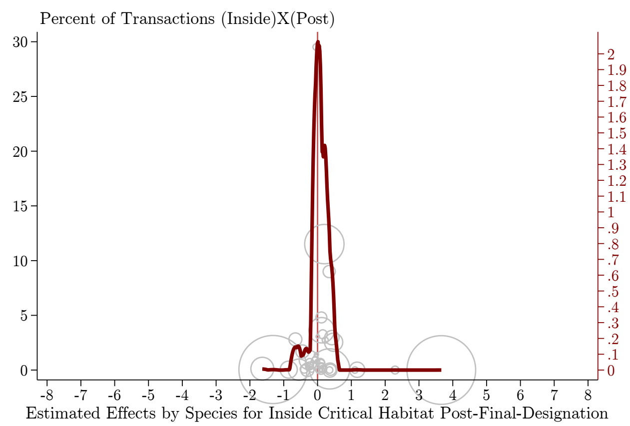
Figure A3: Final Designation Effects Estimated Separately by Species

Residential

(a)

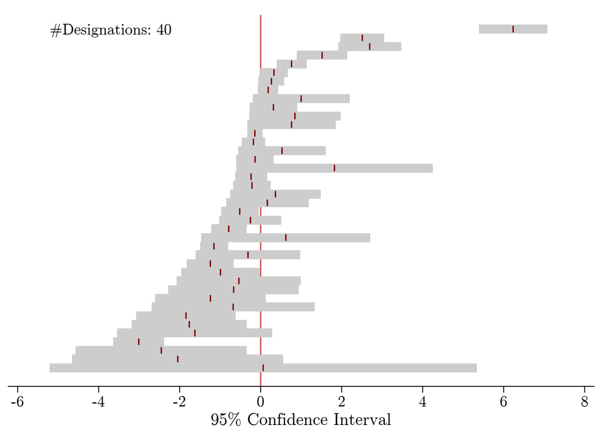


(b)

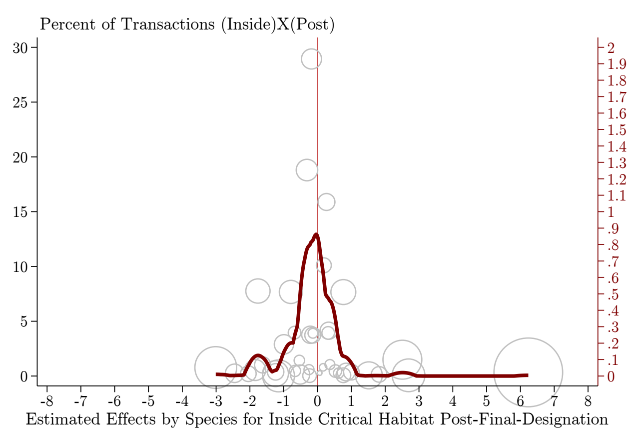


Vacant Lands

(c)



(d)

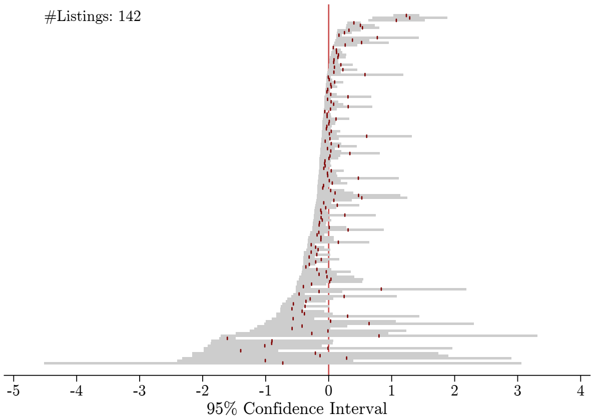


Notes: Estimation results from a similar specification to the on in Equation (3), estimated separately by species. We report the estimates where there were transactions inside the CH, post-final-designation, that allow us to estimate a species specific effect. We include all transactions before the listing proposal, and after the final designation. We include a dummy variable for the time after the listing proposal and up to the final designation, and a dummy variable for the post-final-designation. In the figures, we plot the post-final-designation coefficients and their 95% CIs (left panels). We also plot the coefficients relative to the percent of transactions that are inside the critical habitat, and are sold post-final-designation, with the bubble size proportional to the t-statistic, and the kernel density weighted by the percent of transaction that are inside$\times$post (right panel).

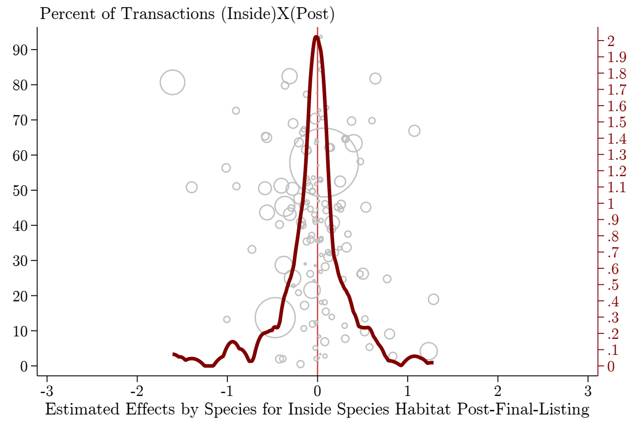
Figure A4: Final Listing Effects Estimated Separately by Species

Residential

(a)

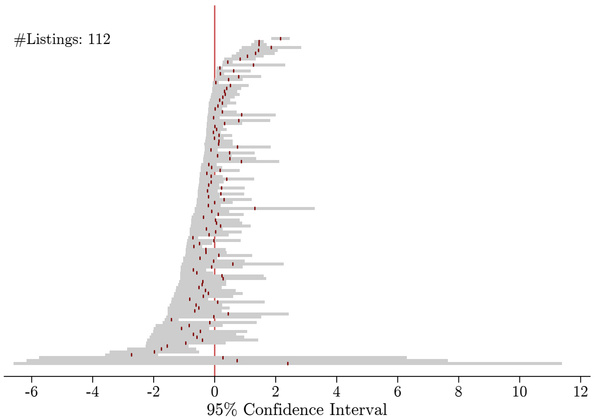


(b)

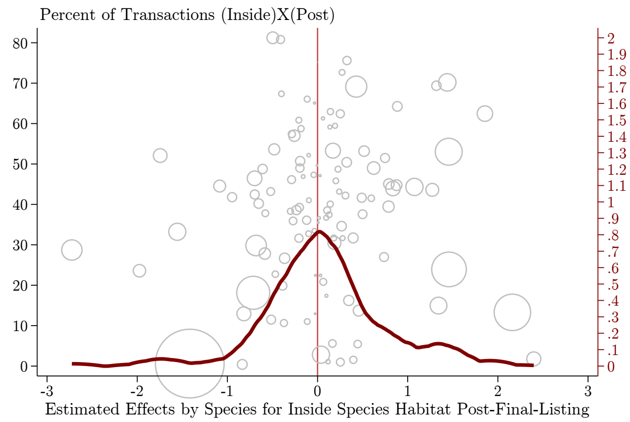


Vacant Lands

(c)



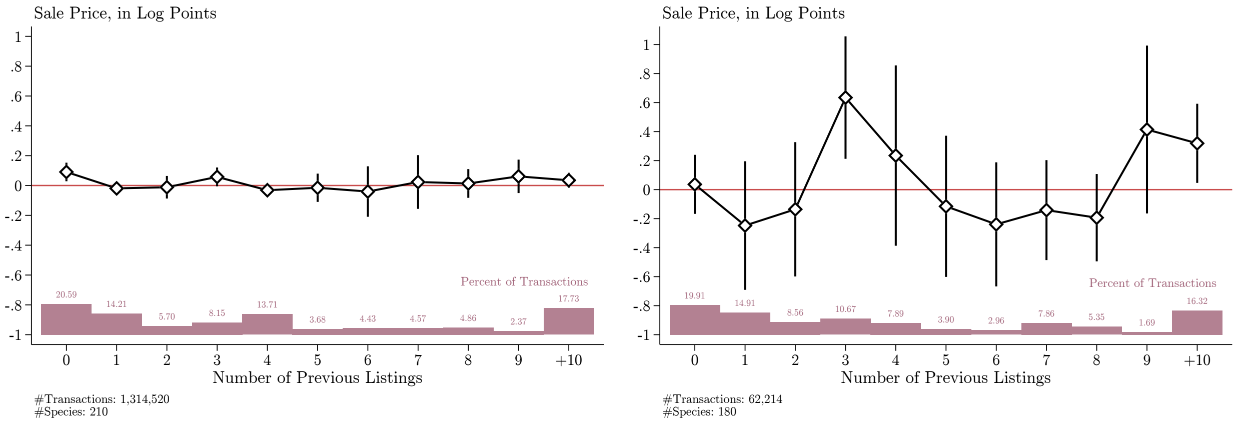
(d)



Notes: See Figure A3

Figure A5: Final Listing Effects by Previous Listing History Length

(a) Residential Properties (b) Vacant Lands



Notes: Estimation results using the specification in Equation (3), interacted with dummy variables for the length of the listing history within each history group. We top code the listing history at eleven histories or more. The sample includes the transaction within a four-year time windows, two years before the listing propsal, and two years after the final listing.

B Data

Here we cover the data and the steps we took in preparing it for analysis in greater detail than in the main text. We begin with the history of listing and designation events under the Endangered Species Act, the pre-processing of shapefiles for species habitats, proceed to discuss the transactions data from CoreLogic, and cover the construction permits data and auxiliary data used in their analysis.

B.1 ESA Listings History

We started with downloading All Reports from FWS Species Data Explorer[21]. The dataset is a near-comprehensive list of rules pursuant to the Endangered Species Act published in Federal Registers. The raw data contains more than 56,000 rows where each row is associated with a unique ESA decision related to one species. Below, we briefly describe the columns that were salient to our dataset construction:

- **Common Name:** Common name of the species
- **Scientific Name:** Scientific name of the species
- **ESA Listing Date:** Date of a species being listed as Endangered or Threatened for the first time. This field is empty if a species has never been listed as Endangered or Threatened.
- **Is Foreign?:** Identifies if a species is found in the US or not
- **Action Type:** Identifies the intended action (listing, delisting, uplisting, critical habitat designation, etc.) of published document
- **Publication Type:** Identifies the nature of ruling (final rule, proposed rule, proposal withdrawal, emergency ruling etc.)

[21] See: https://ecos.fws.gov/ecp/report/adhocCreator?catalogId=species&reportId=species

- **Publication Date:** The date of publication of rule in the Federal Register.
- **Range Shapefile:** Filename for the range shapefile of individual species. This name contains the species identification code and population identification code.
- **Species Group:** Identifies the class of the species (insect, mammal, bird, etc.)

Using the information in the columns above, we first subset the data to species found in the US. Additionally, we remove all rows associated with publications that are not related to listing or critical habitat designation (for example Candidate Notice of Review, Notice of Public Hearing, etc.). We are then left with 7596 observations. Then we exclude all the species that are not found in the Coterminous United States. Finally, we use Publication Type, Publication Date, and Action Type to identify proposed and final rulings of listing, designation, and any modification thereof.

For the most part, we automated the above-mentioned processes using Python and Stata. However, for about 100 species, incomplete or inaccurate information resulted in missing dates or unusual chronology of events (for instance critical habitat designation predating the listing). To solve this issue, we perused the relevant rulings published in Federal Registers, identified the accurate information and manually rectified the dataset.

B.2 Species Habitats and Critical Habitats Data

The critical habitat shapefiles used in this analysis were downloaded from the Fish and Wildlife Service (FWS) Environmental Conservation Online System (ECOS)[22]. These data include two shapefiles, a polygon and a line file. Each contain an identifier (spcode) and a species population id (vipcode) which together are used to uniquely identify a given population of a species. We concatenate these two variables to form a unique identifier (species_pop_id) which is then used to merge in listing and designation dates and other relevant species information.

[22] See: https://ecos.fws.gov/ecp/report/table/critical-habitat.html

B.3 Transactions Data

In the analysis, we use transactions from the CoreLogic Tax and Deed Data. Access to the CoreLogic database is provided by the Becker-Friedman Institute and the Fama-Miller Center for Research in Finance at the University of Chicago.

B.3.1 Pre-Preprocessing CoreLogic

We process CoreLogic data using R version 4.0.1 (2020-06-06) on an Ubuntu server with 64 cores and 378 GB RAM. The CoreLogic data is available in seven .txt files totalling approximately 600 million observations and 160 columns. In our first pre-processing step, we go through the entire raw dataset and use the column FIPS CODE to extract and save observations by state. Second, we identify observations with missing coordinates but that have addresses and re-geocode them using ArcGIS.

B.3.2 Calculating Distances

To complete the distance calculation process within a reasonable amount of time, we first conduct a densification on all boundaries of critical habitats and species habitats. This will replace the curve segments in the boundary lines with a large set of vertices via linear interpolation. We set the maximum distance between the vertices to be 100m. The distance between the properties and the nearest critical habitats and species habitats are calculated based on the kd-tree algorithm in the RANN package in R [23]. The algorithm searches for the nearest point in the set of densified critical (species) habitat points for all properties, and returns both the index of the nearest point and the distance between them. We use the index to find the nearest critical (species) habitat polygon. To determine whether a property is inside its nearest critical (species) habitat or not, we then check whether they intersect with each other. If they overlay, the property is inside the critical (species) habitat

[23] The kd-tree is one of the fastest algorithms for points distance calculation. It runs in $O(M \log M)$ time for M points.

polygon, and we set the distance to be positive. For properties outside the critical (species) habitat polygon, we set the distance negative. Finally, we keep all pairs of property and the nearest critical (species) habitat polygon if their distance is below 10km. We then use the st_join function (sf package) to determine whether a transaction occurs within a critical habitat/species range, or outside. Our current analysis produces distances for all transactions within 10 km of a critical habitat/species range.

B.3.3 Post-Processing

The objective of post-processing is to assign each transaction to one or fewer species ranges or critical habitats. To achieve this, first transaction-range candidates who are within 10 kilometers of a boundary (Panel B of Figure B1) are identified. Second, transaction-range candidates are assigned to treatment or control based on whether they are inside or outside their range (Panel C of Figure B1). Third, transaction timing determines whether an observation is pre-treatment, pre-control, post-treatment, post-control, or contaminated by a previous treatment and ineligible for use in estimation (Panel D of Figure B1). B1 provides a visual description of how the data are constructed for the analysis.

The set of transaction-ranges for a given transaction can contain more than one candidate as some transactions are within 10 kilometers of two or more existing habitats. To remedy this and produce a single range for each transaction, we follow the following procedure. First, transaction-range candidates are only kept that are within 200 meters of the minimum distance for a transaction. This decision rule keeps multiple candidates when boundaries are precisely overlapping, or fuzzy or have slight deviations. Second, the transaction-range candidates are sorted by transaction identifier, listing date, and final listing date (or final designation date in the case of critical habitats). The candidate with the earliest first listing date is kept. If there is a tie for first listing dates, then the candidate with the earliest final listing date (or the final designation date for critical habitats) is kept. This procedure ensures we only assign one transaction to exactly one range, and that range is the closest to the transaction, and corresponds to the earliest treatment. Treatment histories are maintained for each transaction to allow for comparisons between transactions with different treatment statues, but identical histories. In short, a species range boundary can only be used once to identify an average treatment effect or conditional average treatment effect for the earliest range, as transactions for later ranges sharing the same boundary will have different treatment histories.

Our final program merges the transaction data with the species information, distance to habitat, and an inside critical habitat indicator. In this program, census tract fips codes and zip codes are added using the tidycensus package. At this stage we construct a parcel identifier using the following procedure. First we use the unique parcel identifier where available. If missing, we use the assessor parcel number, county name, and state fips code. If the assessor parcel number is missing we use the latitude and longitude.

Finally, we flag and remove duplicates in the data.

B.4 Construction Permits

We obtain data on new residential construction permits from the Census Bureau's Building and Permits Survey (BPS), an annual mail survey of local building permit officials. Approximately 97% of single-family homes built in permit-issuing places are built with a permit; less than 5% of privately-owned housing is built in areas that do not require permits (Census Bureau 2018). The BPS reports the number of residential units permitted, the number of buildings permitted, and each permit's reported valuation. We focus on the counts of units and buildings. These counts can differ due to multi-unit residences, such as apartment buildings. The number of buildings permitted is always less than or equal to the number of units permitted.

The raw data contains missing observations due to non-response from some permit-issuing jurisdictions. The Census Bureau imputes missing data by applying the average growth rate for non-missing data to the previous year's data for the missing jurisdiction. The Census

Bureau also reviews the data to correct any operational errors and ensure consistency. The data are then aggregated the the census place, metropolitan area, county, state, region, and national levels. About 37% of our county-year observations contain imputed data, with an average differences between the imputed and reported counts of 25.6 buildings and 63.7 units. Figure B5 shows the total number of permits issued nationally between 1990 and 2019, including both the raw data series and the time series with data imputed by the Census Bureau. In our regression analysis, we use imputed annual county-level data between 1990 and 2019.

B.4.1 Gridded Population Data

We use gridded population data to aggregate measures of protected area coverage to the county level. Measures include the share of a county covered by species or critical habitats, the total area in a county covered by species or critical habitats, and the unique area covered by species or critical habitats. The distinction between total area and unique area is that total area allows for double counting: if two species habitats contain overlapping areas, we double-count the overlapping area to obtain our total area measure, whereas we count it only once for our unique area measure.

Using population weights to aggregate our protected areas allows us to more precisely measure how much the average undeveloped parcel in a county is exposed to protected land. To illustrate the reasoning behind this procedure, consider two identically-sized counties containing identical amounts of protected land. The first county's protected land overlaps entirely with an urban area, while the second county's protected land is located in a sparsely populated and largely undeveloped part of the county. While the counties' unweighted exposure measures would be the same, the population-weighted exposure measure would be larger in the first county than in the second, reflecting the fact that protected land may have a different impact on building activity in a developed area relative to an undeveloped area. While we recognize that population is an imperfect proxy for residential building activity, we argue that they should be highly correlated. Across most of our specifications, using population-weighted exposure measures yields qualitatively similar point estimates with smaller confidence intervals relative to unweighted measures.

We use NASA's Socioeconomic Data and Applications Center (SEDAC) US Census Grids for our population weights. The US Census Grids downscale census block-level population data to a 30 arc-second (approximately 1 square kilometer) grid. Population is allocated proportionally within a census block. Note that the US Census Grids do not differ from the Global Rural-Urban Mapping Project, another SEDAC data product which uses nighttime lights data to downscale global population to a 30 arc-second grid. The data are available for 1990, 2000, and 2010; we use 1990 data.

We use US county shapefiles provided by the Census Bureau to aggregate our habitat data to the county level. To account for slight temporal variation in county boundaries during our sample period, we use the 2000 county shapefile for 1990-2000, the 2010 county shapefile for 2001-2010, and exact year shapefiles for 2011-2019.

B.5 ACE Permits

Permits issued by the US Army Corps of Engineers (ACE) authorize various types of development projects in wetlands and other waters of the United States. The Corps' regulatory process involves two types of permits: general permits and individual permits. General permits are for actions that will likely have minimal adverse effects and are issued on a nationwide, regional, or state basis for particular categories of activities. Individual permits are for more significant actions that have more than minimal individual or cumulative impacts. Individual permits are evaluated using additional environmental criteria and involve a more comprehensive public interest review than general permits. The focus of our analysis is individual permits, as they deal with actions that have significant impacts and provide spatial variations necessary for identification. To avoid confusion, we use terms "ACE permits" and "individual permits" interchangeably.

Individual permits consist of Letters of Permission and Standard Permits. Letters of Permission are issued through an abbreviated processing procedure which includes coordination with Federal and state fish and wildlife agencies as well as a public interest evaluation, but without the publishing of an individual public notice. Standard Permit must be processed through the public interest review procedures, including public notice and receipt of comments. The decision to issue or deny an individual permit is based on the public interest review and an analysis of the ocean dumping criteria. An Individual permit can possibly get three types of decisions: 1) issued without special conditions, 2) issued with special conditions and 3) denied. The Corps may add special conditions to the permit to ensure that the activity does not jeopardize related laws, including the Endangered Species Act.

Data on the ACE individual permits are obtained from two sources: the data of 1990-2008 are from our FOIA request to the FWS, and the data of 2008-2019 are from the Corps of Engineers regulatory data management system. The data summarize georeferenced records on final and pending permits from every district and division, including complete information on the project name, the permit type, the final action taken by the Corps, the date of issuance or denial, and the location of project (latitude and longitude). The data covers 153,109 records on the pending and final permits of year 1990-2020. Of all ACE permits, 52.3% are issued without special condition, 45.6% are issued with special condition, and only 2.1% are denied by the Corps. 40.4% are Letters of Permission and 59.6% are Standard Permits.

To be consistent with the data availability of critical habitat and species range, we keep ACE permits with final decision made between 1990-2019. Figure B6 plots the spatial distribution of ACE permits across final decisions. We aggregate the data to county level and keep county-year combinations of counties that have ever observed any ACE permit applications in 1990-2019. The removed counties are typically distant from waters and wetlands and cannot be treated by the Corps. This keeps us with 2,839 counties. We construct variables of the number of ACE permit applications, the number of permits across permit types and across final decisions, and the share of permits across final decisions. For county-year pairs with zero applications, we set the share as zero instead of missing value.

B.6 Habitat Conservation Plans

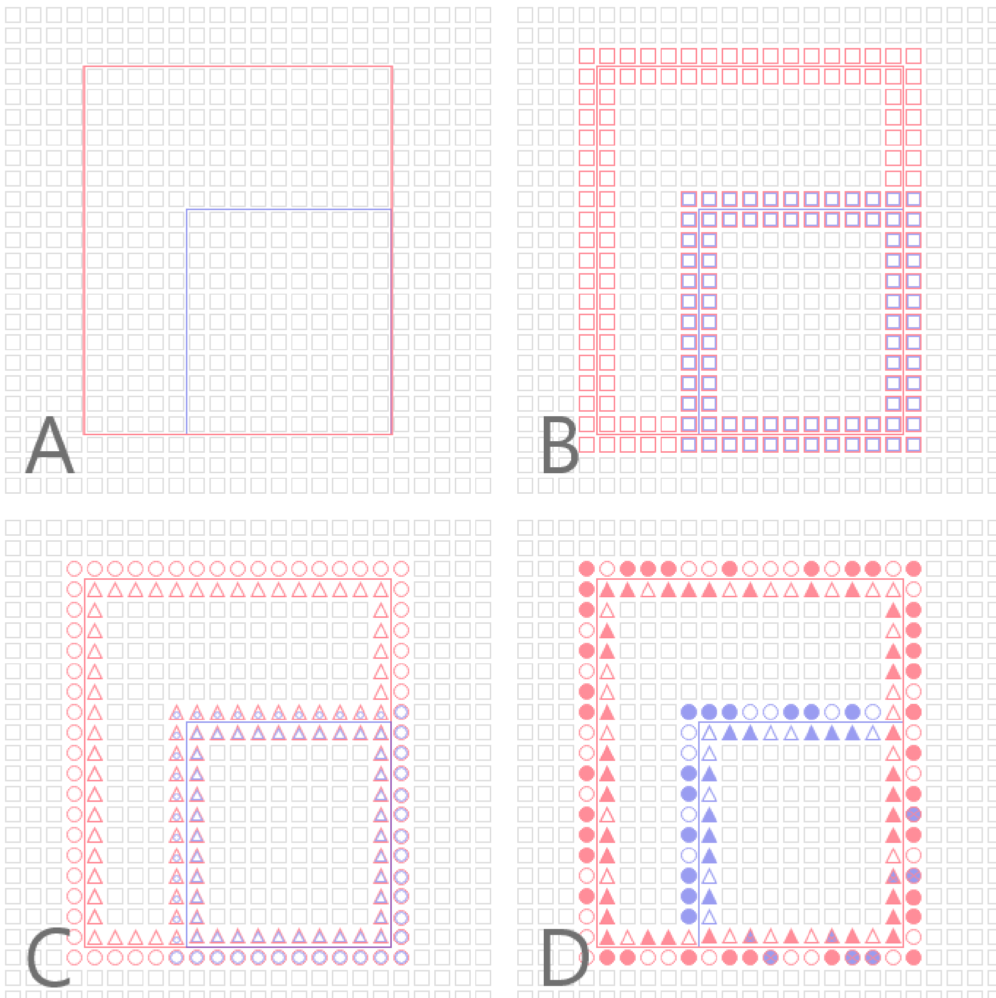
Data on the Habitat Conservation Plans are obtained from a FOIA request to the US FWS. The data contain variables on the HCP title, the status of the plan, the geographic location, the number of acres protected by the plan, the permit number if the plan being approved, the species protected by the plan, the land use covered, the applicant type, and the document linked to the plan. The data also indicate a number of important dates of the plan, including the first assistance regarding the plan being initiated, the complete application package of the plan being received, and the final decision of the permit being made.

The original data contain 49,329 records on document level, so a plan can appear multiple times if there are multiple documents related to it. We first keep only the unique HCPs by removing the duplicated documents. Figure B7 shows the count, by year, of HCP first assistance, application and permit decision over time, of all unique HCPs between 1990 and 2020.

To measure the timeline of each plan, we construct a variable on the number of years between the the date on which the first assistance of the plan was initiated and the date on which the permit decision was made or the application was withdrawn. We keep only records with a non-missing HCP timeline, so the plans of which the final decision on the permit issuance have yet been made are removed from the sample.

We link the HCP data with the ESA treatment data by matching the species name, and construct a number of dummies on the species type, including whether the species covered by a plan is an animal species or a plant species, whether the species is ever designated for critical habitat, and whether the species is ever listed by the FWS. Using the first assistance date of the plan and the designation date of the critical habitat, we construct a dummy on whether the plan is submitted before the species being designated. To study how the effect changes by administration, we create a dummy on whether the HCP is initiated before the end of year 2000. The final data covers 7,815 unique HCPs with non-missing values on the HCP timeline and on the ESA treatment status.

Figure B1: Descriptive Diagram of Construction of Data for Critical Habitat and Species Ranges



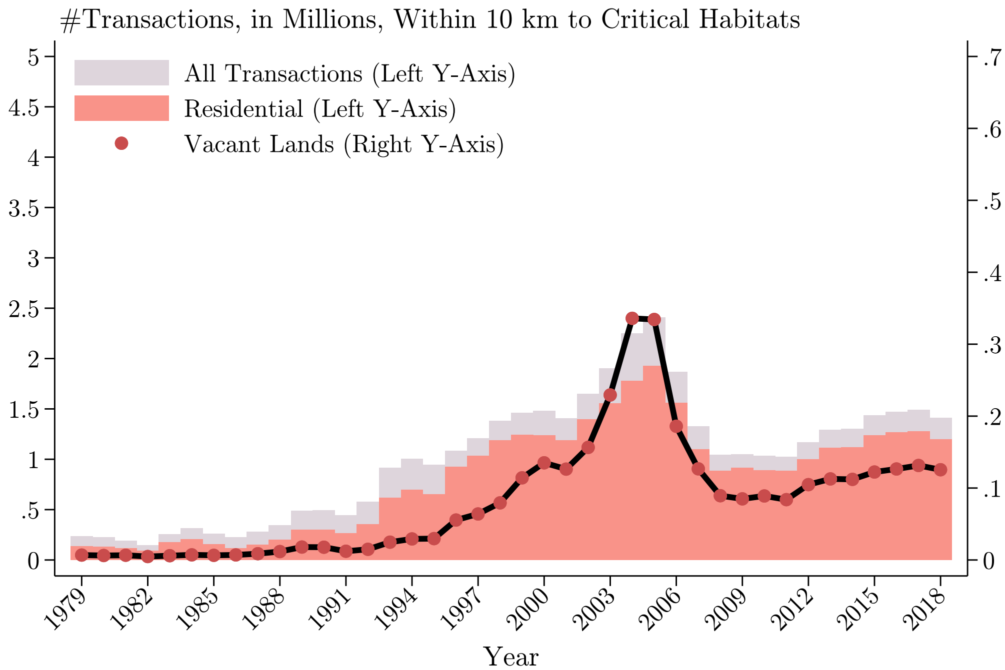
Notes: The objective of this approach is to assign each transaction to a single range. In panel A, let gray squares represent transactions and the blue and red boundaries represent species ranges. Let the red species range occur before the blue species range. Note this implies the blue range overlaps the red range. In panel B, distances are calculated for each transactions to all ranges. Only transactions within a given distance (10 km) of any range comprise the list of candidate transaction-ranges. Transaction-range candidates in the diagram are assigned the color of the range. Note in panel B that some transactions are candidates for both the red and blue ranges (red squares with blue squares inscribed). Panel C shows how transactions are assigned to inside (triangles, treated) or outside (circles, control) their respective ranges. Panel D illustrates four key concepts. First, timing of the transaction relative to the listing date of the range to assign the transaction to before (hollow shapes) or after (solid shapes) range listing. Second, when boundaries are shared spatially (see the lower right corner of the red range), the candidate with the earliest listed range (red) is kept. Third, the upper left corner of the blue range is inside the red range, but does not share a boundary with the red range, and can therefore be used for estimation of the marginal effect of the blue range conditional on already receiving the red treatment. Fourth and finally, transactions that occur after the red and blue ranges (circles and triangles with blue fill and a red crosshatch) at a boundary shared by the red and blue range are unable to be used to estimate the treatment effect of either range, and are identified and removed from the analysis.

Figure B2: Visualization of Transactions and Treatment Status for Species Range Boundary

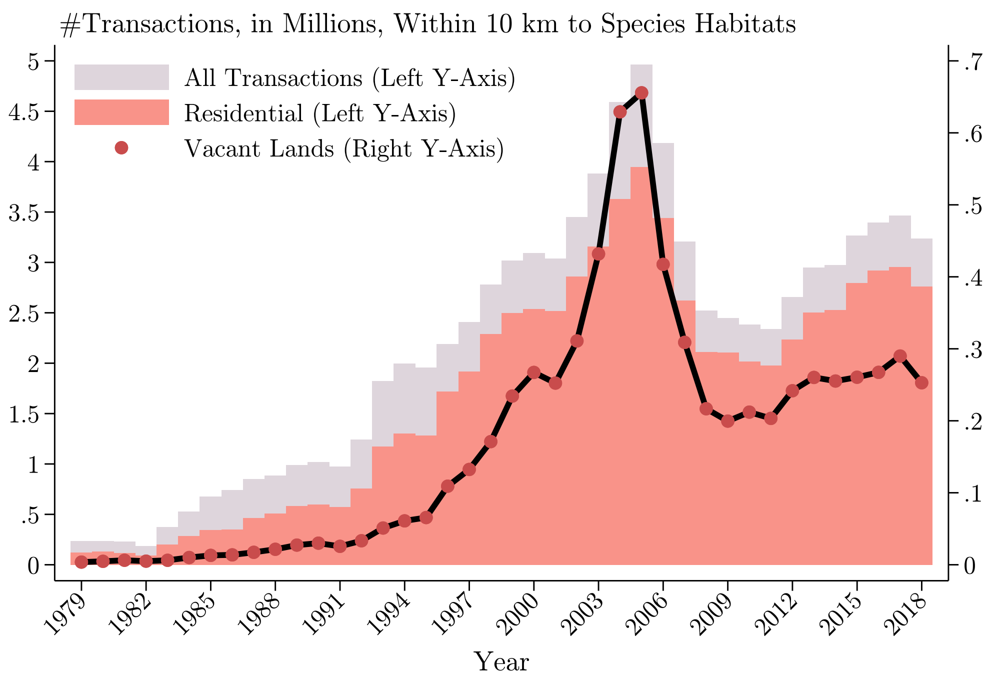
Notes: This figure plots actual data and is from species range boundary in California. The shapes are circles for control group transactions, and triangles are treatment group transactions. The hollow shapes are transactions that occur before treatment, and the solid shapes are those that occur after treatment. The green (treated) and orange-brown (control) colors are there to show observations are neatly bisected by the species range boundary.

Figure B3: Summary of Transaction Counts for the Contiguous US

(a) Critical Habitats



(b) Species Habitats



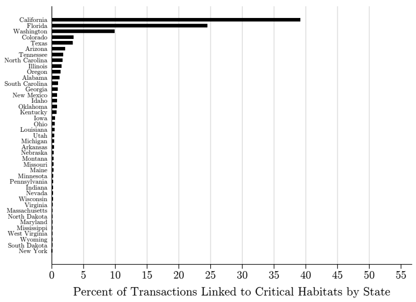
Notes: The total number of transactions, by type, by year, for properties that are within 10 km to a critical habitat border (a), or to a species habitat border (b).
Source: CoreLogic Tax and Deed History Data. Data on species and critical habitats from the FWS.

Figure B4: Share of Transactions Across States, by Land-Use, by Sample

Critical Habitats

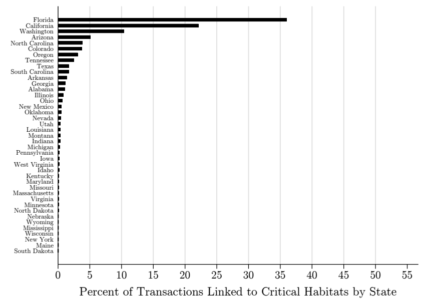
Residential

(a) Full Sample

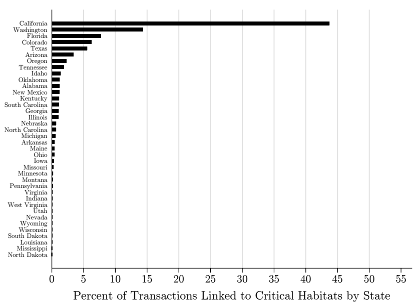


Vacant Lands

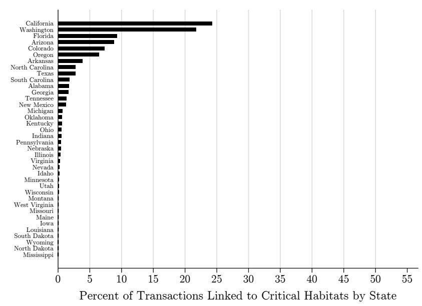
(b) Full Sample



(c) Four-Year Window Sample



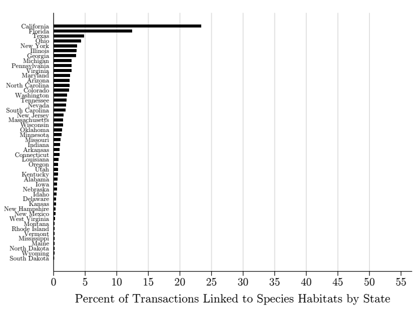
(d) Four-Year Window Sample



Species Habitats

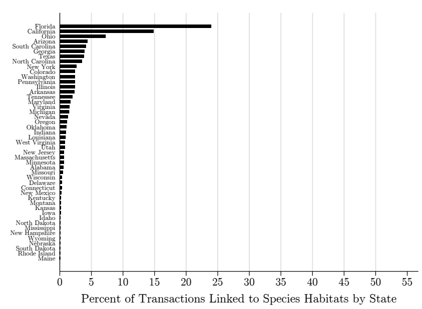
Residential

(e) Full Sample

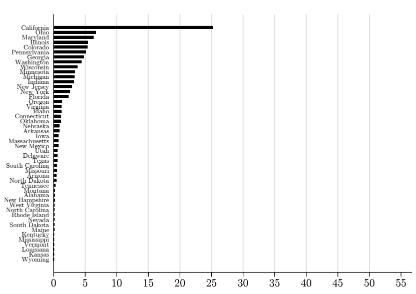


Vacant Lands

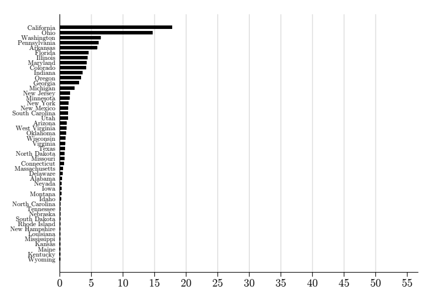
(f) Full Sample



(g) Four-Year Window Sample



(h) Four-Year Window Sample



Notes: Share of transaction by state for either the full sample, or the sample centered around two years before the listing proposal, and two years after either final designation (critical habitats), or final listing (species habitats).

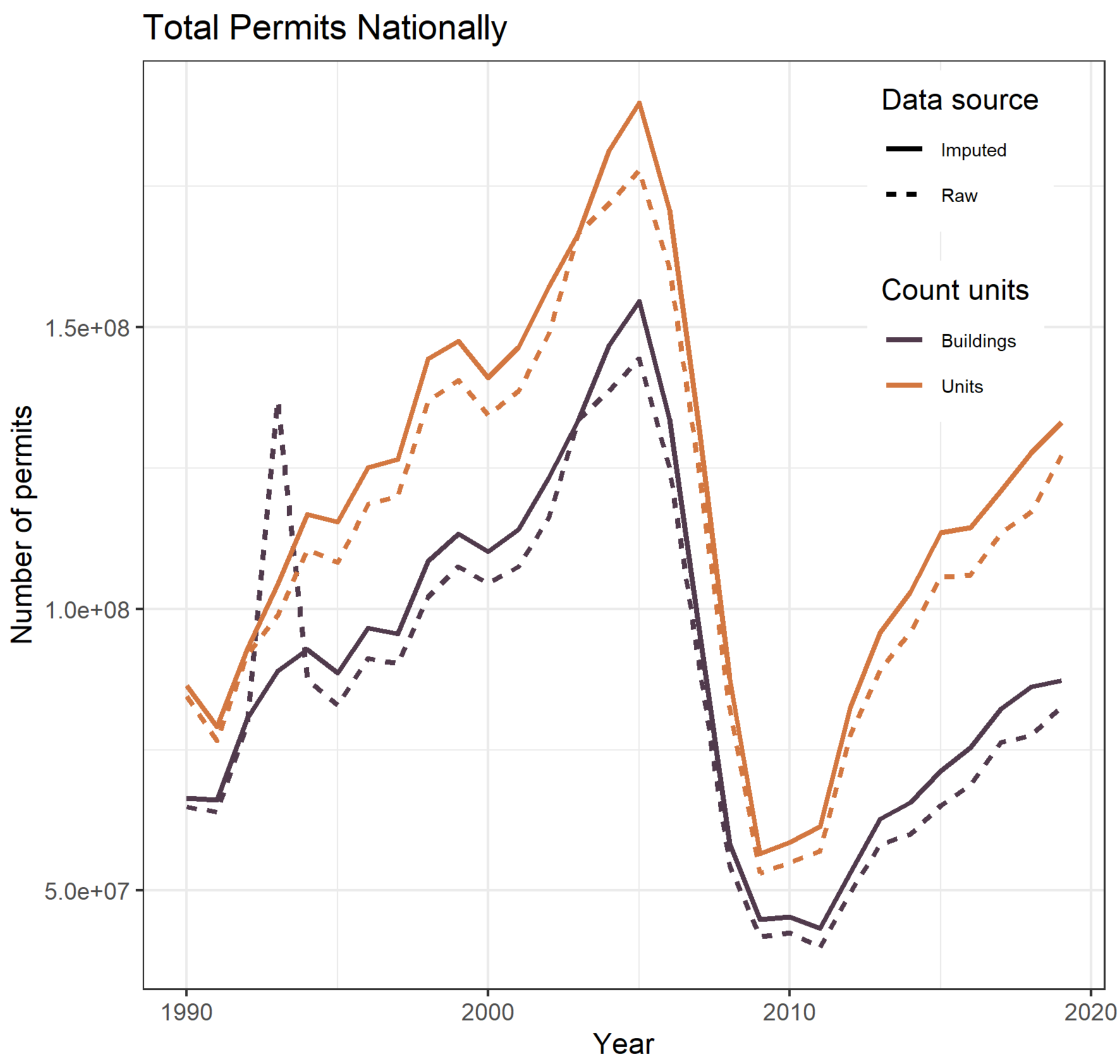


Figure B5: Time series of total new residential construction permits

Notes: the total number of buildings and units permitted in the United States between 1990 and 2019. Both raw data and data which has been processed by the Census Bureau, including imputing missing values, are plotted.

Source: Census Building and Permits Survey

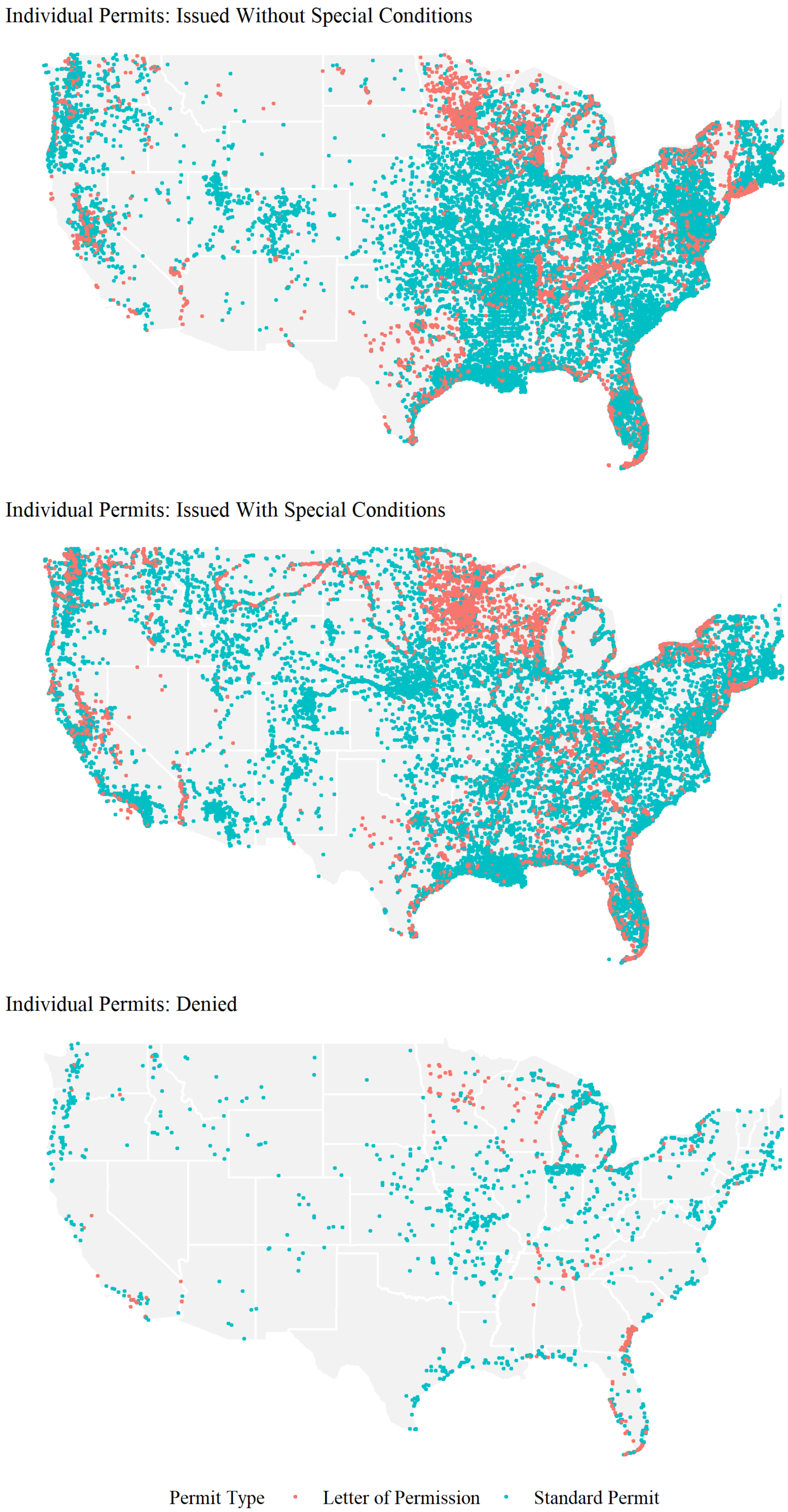
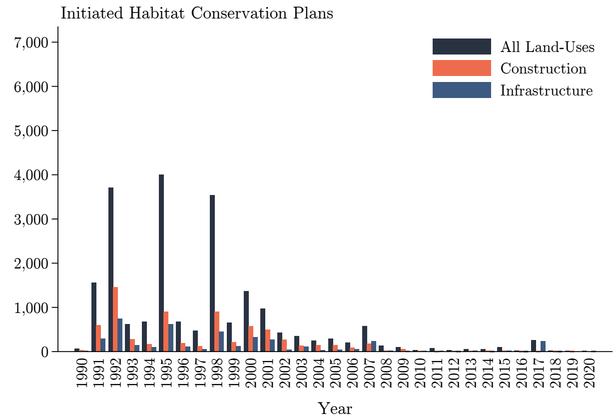


Figure B6: Distribution of ACE individual permits

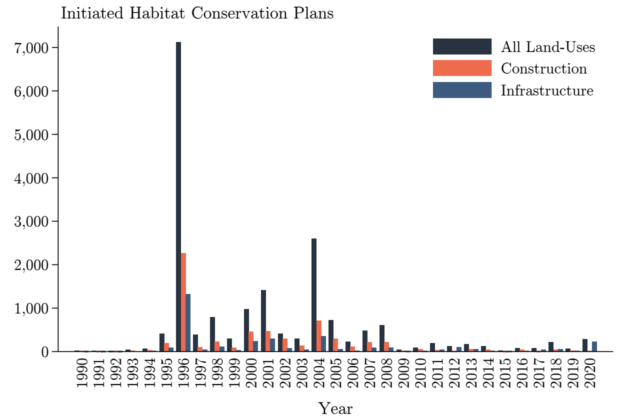
Notes: ACE permits with final decision made between 1990 and 2019 in the contiguous US. Source: Corps of Engineers regulatory data management system and our FOIA request to the US ACE.

Figure B7: Habitat Conservation Plans, by Year, by Land-Use

(a) Initiated First Assistance



(b) HCP Permit Issuance



Notes: The number of HCPs initiated or permitted by year, for all land-use categories, any construction (residential or commercial), or infrastructure projects.
Source: Conservation Plans and Agreements Database from the FOIA request.