The effect of endangered species regulations on local employment: Evidence from the listing of the lesser prairie chicken

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Abstract

The U.S. Endangered Species Act is often criticized as pitting people against species by conserving habitat at the cost of jobs. Critics of current conservation policies argue that the protection of species is stripping landowners of their property rights and putting people in industries tied to resource extraction out of jobs. While changes in employment are important measures of the public costs of endangered species protection, relatively little is known about the labor market impacts of listing a species under the Endangered Species Act. We examine changes in employment associated with the lesser prairie chicken, an imperiled bird that was listed as threatened in May 2014. Using monthly county-level employment data and variation in potential prairie chicken habitat, we apply a difference-in-differences strategy to measure the employment impacts of the listing decision. We find evidence that employment declined after the listing by about 1% in counties with habitat relative to non-habitat areas. We also find that the impact is proportional to habitat, so counties with the most prairie-chicken habitat experienced the largest impacts on employment.

Keywords: Conservation; habitat; growth; Endangered Species Act
JEL codes: E24; J21; Q24; Q52;

1 Introduction

Endangered species conservation has a controversial yet poorly understood connection to the broader economy. There has been an upward trend in species extinction rates and current estimates are that one-fifth of all species are endangered, meaning those species are likely to become extinct in the near future. Without conservation, this number would be substantially higher [1]. Habitat modification from human activity is the greatest contributor to the decline of most species [2]. As a result, conservation policies focus on protecting endangered species habitat by: 1) managing public lands to serve as wildlife habitat; and 2) regulating private land use. Both of these policies invite controversy, as discussed in the next section. In particular, regulating land use to protect endangered species is controversial because the costs often tend to fall disproportionately on private landowners and developers [3]. There is widespread public concern that protecting wildlife damages local industry and labor markets [4,5]. Considering the scope of the conservation issue and the amount of public backlash, there is remarkably little published research quantifying the effects of endangered species regulations on local economic development.

This paper contributes empirical evidence to this controversy by estimating the local employment consequences of listing an endangered species in the United States. Under the U.S. Endangered Species Act (ESA), species listed as endangered or threatened cannot be harmed, which includes acts that kill, injure or significantly modify habitat essential to the species [6]. The threat of regulatory restrictions and substantial civil and criminal penalties places a burden on landowners and industries that rely on natural resources. Many Americans fear listing a species restricts development and raises unemployment in areas with protected habitat [5, 7]. We test whether this hypothesis holds for the lesser prairie chicken, whose habitat in the Great Plains intermixes with farms, ranches and energy structures such as wind turbines. We hypothesize employment in areas occupied by the lesser prairie chicken declined following the species' listing.

A large and growing research effort is investigating the economic impacts of environmental policies and environmental change using quasi-experimental methods [7,8]. Concerns about omitted variable bias have pushed empirical researchers to adopt techniques such as instrumental variables and difference-in-differences—which have a long history in public and labor economics—to identify causal relationships in economic activity [9]. Recent applications in environmental economics have used these methods to identify the effects of acid rain regulations on the behavior of polluting firms [10–12], carbon emission regulations on low-carbon technology development [13], natural amenities and landscape change on residential property values [14–18], shale gas extraction on local employment and wages [19, 20], and farmland subsidies on the adoption of green-farming practices and ecosystem services [21, 22]. Fixed effects and instrumental variables techniques have also been used to value environmental quality in the demand for outdoor recreation [23, 24]. Our study contributes to this literature by applying a quasi-experimental method to measure the local labor market impacts of ESA regulations, an important question in economics that has received little study.

The literature on the economic impacts of ESA regulations may be limited, but most research suggests a tradeoff exists between species conservation and jobs.[1] Most of these papers are found in the grey literature and describe input-output or computable general equilibrium models to predict *ex ante* production and employment impacts of impending listings [27, 28] or designating critical habitat [29, 30]. In addi-

[1]There are also several papers that examine the impacts of the ESA and related policies on the real estate market. See Greenstone and Gayer [7], Meyer [25], and Zabel and Paterson [26].

tion to an early study by Freudenburg [31], Eichman et al. [32] is a notable departure in that they conduct an econometric investigation using real-world data. Specifically, they examine changes in local employment growth and net migration due to the creation of the Northwest Forest Plan to protect Northern Spotted Owl habitat from timber harvests. Protecting the owl incited a national debate about the economic impacts of ESA regulations when the species was listed as threatened in 1990 [25]. Eichman et al. find evidence that the regulations restricting harvests on public land directly reduced local employment growth in the U.S. Northwest. The Northern Spotted Owl serves as an example of how controversial and costly endangered species protections can be on public lands.

This paper provides estimates of the employment impacts from listing an endangered species whose habitat is found mainly on private lands. Specifically, we focus on the case of the lesser prairie chicken, a grassland bird native to the southern Great Plains that was recently listed as an endangered species. In this case, farming, ranching and energy development are the main economic activities threatened by ESA regulations. Our identification strategy takes advantage of the month the listing occurred plus a spatial habitat assessment used by state agencies to inform landowners and developers about the range of the lesser prairie chicken. At the time of listing, individuals and firms had access to information on which privately owned lands were likely to be burdened by ESA regulations. Combined with panel data on county employment levels drawn from the BLS Quarterly Census of Employment and Wages, this information allows us to use difference-in-differences to test whether the number of jobs in counties with lesser prairie chickens declined because of the listing. We find evidence employment did change, by about 1% in counties with habitat, and that the magnitude of the effect varies proportionally with the amount of habitat in a county. We also examine employment dynamics and the timing of conservation actions prior to the listing. We find evidence that conservation actions may have affected job growth even before ESA regulations went into effect, although it is also possible some employers limited hiring in anticipation of a listing.

The paper proceeds as follows. The next section provides a short history of ESA controversies. Section 3 provides some background on lesser prairie chicken conservation. Section 4 describes the empirical strategy and the data. Section 5 presents the results. Section 6 discusses the results and concludes.

2 The Endangered Species Act

The ESA is Congress' attempt to prevent extinction events in the United States. The ESA, passed with bipartisan support in 1973, is the product of several earlier laws, including the 1966 Endangered Species Protection Act and the 1969 Endangered Species Conservation Act. The Act of 1966 was the first to authorize the Secretary of the Interior to develop a list of endangered species; these species received protection from destruction of habitat on federal lands. The 1969 Act allowed the Secretary of the Interior to list foreign species and prohibited interstate commerce involving listed species or their products. However, a consensus emerged that these protections were insufficient, leading to a complete re-write of the law, which became the Endangered Species Act of 1973. The ESA expanded the listing categories to include endangered and threatened species, and prohibited any act of harm to listed species, including those on private lands.[2] The U.S. Fish and Wildlife Service (FWS), the agency tasked with listing and protecting non-marine species, interprets the definition of "harm"

[2]The Act defines endangered as a species in danger of extinction throughout all or a significant portion of its range, while a species listed as threatened is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

broadly to include the destruction of species habitat.[3] The Act further authorizes the FWS to designate critical habitat so as to explicitly define areas essential to the conservation of a listed species. The ability to prohibit harm and, to a lesser degree, designate critical habitat provide the FWS with powerful regulatory instruments for conservation.

Today, the ESA is a controversial and highly partisan environmental law [33]. This was not true at the time it was written—the law passed the Senate with a vote of 99 to 1— but several famous conflicts turned species listings into a contentious and high-stakes process. Just a few years after the ESA's passage, conflict erupted over a small fish known as the snail darter. The fish was listed in 1975 because its range was restricted to a single section of one river. At the same time, the Tennessee Valley Authority was completing a dam that would inundate and destroy the snail darter's habitat. The conflict culminated in a lawsuit widely covered in the media as a "classic struggle between ecology and economics" that eventually reached the U.S. Supreme Court [34].[4]

A similar controversy exploded in 1990 over the listing of the Northern Spotted Owl. The owl resides in old-growth forest in the U.S. Northwest that also serve as important stock for the timber industry. A large number of studies predicted protecting the owl would cost tens of thousands of industry jobs [5], and that with many communities in the area dependent on logging and timber milling the total impact could be in the hundreds of thousands of jobs [25]; subsequently, "jobs versus owls" became the slogan for anti-ESA politics. President George H. W. Bush famously

[3] This interpretation was upheld by the U.S. Supreme Court in Babbitt v. Sweet Home, 515 U.S. 687 (1995).

[4] The Supreme Court effectively ruled in favor of the ESA but its decision prompted Congress to exempt the dam from ESA restrictions. Biologists relocated a part of the snail darter population, which likely saved the species from extinction as the original population was extirpated when the dam was completed.

commented “We’ll be up to our necks in owls, and every millworker will be out of a job.” While the President’s remark was obvious hyperbole, it testifies to the public’s focus on job impacts as a critical measure of the costs of protecting endangered species.

3 The Lesser Prairie Chicken

The lesser prairie chicken is a long-standing species of concern. The grassland bird lives in parts of Colorado, Kansas, New Mexico, Oklahoma, and Texas, much of which is dominated by agriculture. By the end of last century, conversion to cropland and intensive grazing practices had reduced and fragmented the species’ habitat so that it totaled about 17% of the historical range, with population declines of up to 90% [35]. In 1995, the FWS received a petition to list the species as either threatened or endangered. The agency determined a listing was warranted but delayed acting on it because resources were focused on higher priority species. However, emerging energy development accelerated habitat loss and prompted the agency to issue a proposal to list the species as threatened in December 2012. The lesser prairie chicken has a strong aversion to vertical structures, probably as an instinctual defense against birds of prey, so wind towers and oil and gas wells can be extremely disruptive [36].

In response to increasing habitat threats and the proposed ESA listing, the Western Association of Fish and Wildlife Agencies (WAFWA) developed the Range-wide Plan [35]. The cornerstone of the Plan is a conservation program that offsets habitat losses with new habitat brokered through voluntary land use agreements. Funding for these agreements comes from mitigation fees that developers pay to participate in the Plan, so that their projects qualify for the ESA’s 4(d) rule, which exempts take as long as doing so supports conservation for the endangered species. By “developers” we refer to individuals and companies that use land for mineral, oil and gas, wind energy and agricultural production. Such developers often lease rather than own land but their activities are still subject to ESA regulations in the event of a listing. By participating in the Range-wide Plan developers can significantly reduce the risk of litigation from a take. The Range-wide Plan was implemented soon after the FWS announced in May 2013 that if the lesser prairie chicken was listed (which at the time was still uncertain) exceptions would be allowed under the 4(d) rule.

The Range-wide Plan's mitigation program is an adaptation of the FWS's Candidate Conservation Agreement with Assurances (CCAA) program, which encourages landowners to engage in conservation activities prior to a listing. CCAAs are commonly used by the FWS as a pre-listing conservation tool, and were originally developed to address the problem of landowners destroying endangered species habitat to avoid ESA restrictions. A traditional CCAA provides participating landowners and developers with an assurance that if they complete certain conservation activities they will not be subject to additional restrictions if the species is listed under the ESA in the future [37]. Developers can participate in the Range-wide Plan through a WAFWA Conservation Agreement (WCA) or, if they are a oil or gas company, a WAFWA CCAA. The obligations under the two agreements are identical: both provide regulatory assurances in the event of a listing, but unlike a traditional CCAA participating developers are not obligated to undertake conservation activities; instead, conservation is carried out by landowners (generally, farmers and ranchers) through agreements arranged by state wildlife agencies [35].

WAFWA's Range-wide Plan was expected to convince the FWS that a listing was unnecessary to avoid further habitat losses. The FWS officially endorsed the Plan and in December 2013 published a revised listing rule to clarify in regards to the Range-wide Plan the exceptions that would be permitted under a listing. As a result, enrollment in the WCAs and WAFWA CCAAs started in January and March, respectively, of 2014.[5] However, in late March 2014 the agency announced the lesser prairie chicken would receive threatened species status, which was officially conferred in May 2014.

The decision to list the lesser prairie chicken was widely criticized by industry [38]. Within a month of the listing, there were reports that the decision was having an effect on drilling decisions and energy jobs [39]. Developers and politicians argued that the threatened species status would hinder economic development in rural areas with habitat. One petroleum group publically stated ESA "regulations would impede operations and cost hundreds of millions of dollars in oil and gas development in one of the country's most prolific basins," while a U.S. Representative argued "as the American economy continues to struggle, our actions should encourage growth not hinder economic efforts" [40]. Several lawsuits challenged the listing decision, including one that resulted in the listing being overturned by a Texas federal judge in September 2015 [41].

ESA regulations or even the threat of regulations can impact employment by reducing the expected net benefits of development. The fact that developers participate in costly conservation programs at all is evidence that ESA regulations are perceive as damaging. In 2014, WAFWA received about $40 million in enrollment fees from the Range-wide Plan. Because lawsuits against companies accused of a take are rare (so informed employers probably recognize the chance of litigation is small) the total expected damages from lesser prairie chicken regulations could be an order of magnitude greater than the fees collected. Employers will respond to these costs by

[5] One of the differences between the WCA and CCAAs is that enrollment in the latter is not possible after a species is listed. In contrast, companies can enroll in a WCA at any time.

adjusting their investment and hiring decisions, although timing matters: developers who enroll in CCAA-type programs must change their behavior before ESA regulations are announced, while developers who forgoe assurances may wait to respond until the listing occurs.

Graphical analysis suggests a shift in employment growth did occur following the listing of the lesser prairie chicken. Figure 1 presents a time series of employment between 2011 and 2014 in counties that contain at least some lesser prairie chicken habitat. In the period covered by our analysis, employment in the habitat region was increasing by about 2% annually prior to May 2014. However, employment growth slowed in the second half of 2014. As the figure shows, a downward shift in the trend occurs around the time the species was listed. Of course, the figure does not prove causality, but it is certainly consistent with the idea that ESA regulations can influence the labor market.

4 Empirical Strategy

We measure the local labor market impacts of listing the lesser prairie chicken under the ESA by comparing employment trends in counties with and without habitat. A decline in labor demand is expected in counties with lesser prairie chicken habitat following the listing. To test this empirically, we estimate a difference-in-differences model with the specification:

$$\ln(\mathrm{Y}_{it}) = \gamma_i + \tau_t + \delta\big(habitat_i \cdot listing_t\big) + \beta \mathrm{X}_{it} + \epsilon_{it}, \tag{1}$$

where Y_{it} is employment in county i in month t; γ_i are county fixed effects; τ_t are time effects; $habitat_i$ is a measure of the habitat area; $listing_t$ is a dummy that takes

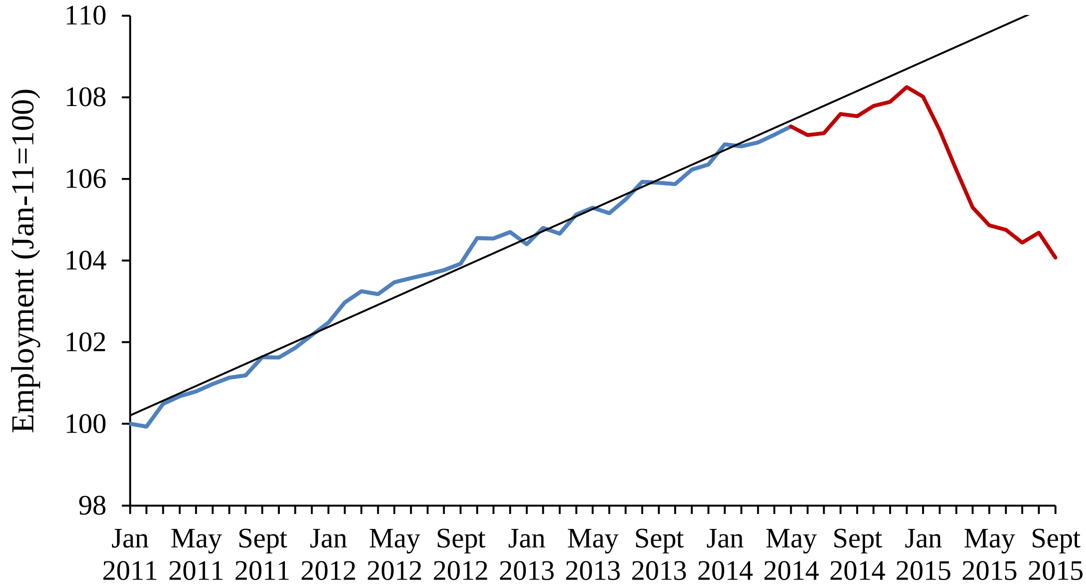

Figure 1: Employment growth in counties with lesser prairie chicken habitat, seasonally-adjusted and indexed to January 2011. The straight line measures the trend prior to May 2014, when the FWS listed the lesser prairie chicken as a threatened species. The employment losses observed in 2015 are probably due to the steep decline in global crude oil and natural gas prices that began in mid-to-late 2014. The petroleum industry is a major employer in Oklahoma and Texas, two states which together contain about half of all lesser prairie chicken habitat.

the value of 1 if the month is May 2014 or thereafter; and X_{it} are additional controls varying over geography and time. We estimate equation (1) by OLS.

We also estimate an alternative albeit analogous model specification to address a potential problem in using OLS to estimate equation (1). Only under a specific heteroskedastic error distribution will the OLS log-linear parameter estimates be consistent [42]. In general, we expect heteroskedastic errors in dealing with employment in rural settings, as the errors should attenuate with smaller employment levels, but we would prefer an estimator robust to distributional assumptions. We therefore estimate an exponential model

$$\mathrm{Y}_{it} = \exp\left[\gamma_i + \tau_t + \delta\big(habitat_i \cdot listing_t\big) + \beta \mathrm{X}_{it}\right] + \eta_{it}, \tag{2}$$

using the Poisson pseudo-maximum-likelihood (PPML) estimator with two-way fixed effects. The PPML estimator remains consistent under conditions of heteroskedasticity as long as the conditional mean is correctly specified [43]. The dependent variable does not have to be Poisson distributed nor does it need to be a count. For inference that does not rely on the Poisson variance assumption and is robust to arbitrary patterns of serial correlation, it is best to use a sandwhich estimate of the standard errors, as described in Wooldridge [44]. See Santos-Silva and Tenreyro [45] for an application of the PPML with difference-in-differences.

Information about the distribution of lesser prairie chickens was obtained from the Kansas Biological Survey. The Kansas Biological Survey has worked extensively with WAFWA to document areas of occupied and suitable habitat. This data is made available through the Southern Great Plains Crucial Habitat Assessment Tool (SGP CHAT), a spatial model that classifies areas of lesser prairie chicken habitat in the five state region [46]. The SGP CHAT includes an online map function that shows the locations of priority habitat. The online interface was developed to inform the public and encourage development projects in sensitive areas to participate in the Range-wide Plan, as the vast majority of habitat is contained on private land [35]. The SGP CHAT was published in 2013, so industry and the public had access to information about the distribution of the lesser prairie chicken at the time the species was listed.

Based on the SGP CHAT, there are 90 counties containing at least one acre of habitat. Kansas contains the largest share, followed by Texas, Oklahoma, New Mexico and Colorado. This allocation closely mimics the population distribution, with about half of the total number of lesser prairie chickens living in Kansas, followed by Oklahoma, Texas, New Mexico and Colorado [35]. The median county in the SGP

CHAT has more than 50% of its land area designated as habitat.

We consider two different definitions of the treatment area $habitat_i$. First, $habitat_i$ is constructed as an indicator equal to one for counties with at least 1% of land designated as habitat in the SGP CHAT. The coefficient δ thus becomes the difference-in-differences estimate of the change in employment due to the listing event. Second, $habitat_i$ is measured as the fraction of designated habitat in a county. In this case, δ measures the marginal change in employment attributable to more habitat. One would expect that if listing a species under the ESA causes a decline in local employment, then counties with more habitat should experience greater declines in employment.

For employment information we use monthly county-level data from the Quarterly Census of Employment and Wages (QCEW). The U.S. Bureau of Labor Statistics conducts the QCEW using administrative data from employers who pay unemployment insurance premiums. The census database includes monthly employment and quarterly counts of establishments and average wages for every county in the United States. Employment is determined by place of work and measures total jobs—so a person holding multiple jobs is counted multiple times. The data do not include self-employed persons or farmers, ranchers and military personnel, although hired farm workers are included. Initially, we define the dependent variable as employment across all industries. The QCEW provides industry-specific employment data, so later in the paper we restrict the definition to employment in natural resources and construction, which correspond to NAICS supersectors 10 and 20, respectively. The QCEW suppresses employment data for industry subclassifications in regions with limited numbers of establishments, which precluded us from examining employment trends within more specific industries.

For a control we use counties in the affected states that are economically and topographically similar to habitat counties. Specifically, the comparison group consists of counties in the five state region that averaged less than 50,000 workers in the 2011-2014 period, with at least 5% employed in the natural resources sector, and that fall within the Natural Resource Conservation Service's Prairie Grasslands Region, which effectively removes coastal and mountainous counties. As shown in Table 1, these refinements result in a comparison group that is comparable to the treatment in terms employment levels, potential agricultural and energy production, and employment growth.

For δ to be a credible estimate of the local labor market impact of the listing, the employment trends in habitat and comparison counties must have been similar prior to the listing. Comparison counties are slightly more populated than habitat counties but growth rates are similar. We empirically tested the common-trend assumption by measuring the differences in comparison and treatment groups pre-listing in the manner of Autor [47]. Between January 2011 and April 2014, there was only one month in which there was a statistically significant difference between the two groups, indicating employment in habitat and comparison counties generally grew at the same rate prior to treatment.[6] Figure 2 provides graphical evidence of this parallel trend. In contrast, there were some measured differences in the months between 2005 and 2011 that were negative and statistically significant.[7] For this reason we test for a causal employment effect using the post-2010 QCEW employment data.

[6]These are the OLS results. Using PPML, there were no months in which there was a statistically significant difference.

[7]Growth was somewhat slower in habitat counties, and differences tended to be significant using the PPML.

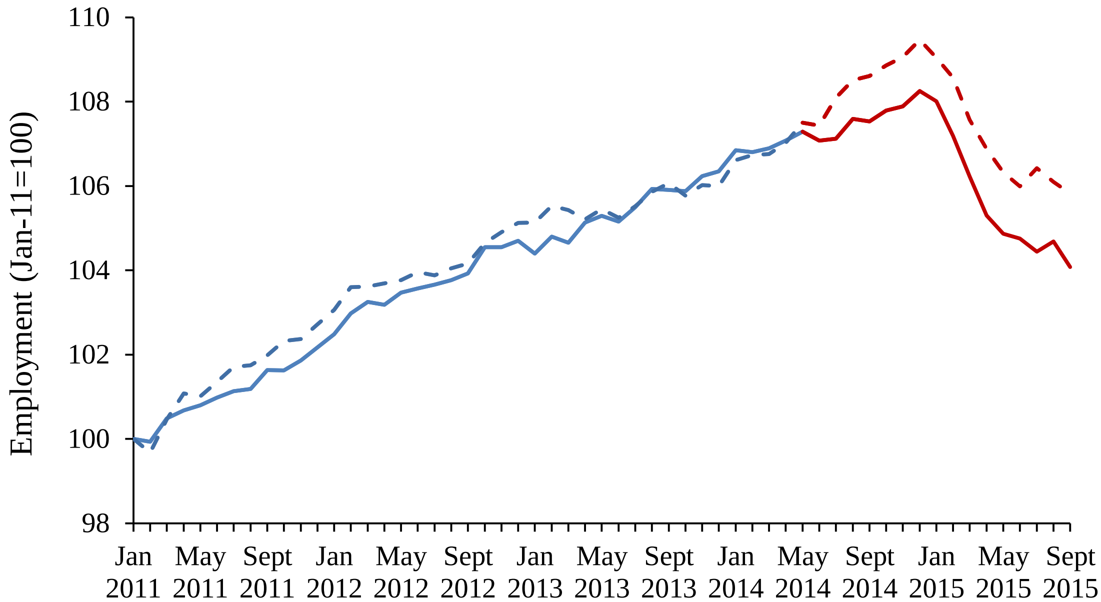

Figure 2: Employment growth in habitat counties (solid line) and comparison counties (dashed line), seasonally-adjusted and indexed to January 2011.

5 Results

Primary results

Our estimates suggest ESA regulations negatively affect employment. Initial estimates of equations (1) and (2) without any covariates (X) are presented in Table 2. Each cell presents a unique estimate of δ, depending on the habitat definition and estimator. The first row contains the OLS estimates and the second row contains the PPML estimates. Proceeding across the first row, the coefficient of -0.013 in the first column indicates employment in habitat counties changed by a relative -1.3% according to the log-linear model.[8] The second column presents the same result except that a habitat area-specific trend is included in the model, which functions in the same

[8] The percent change in employment when δ switches from 0 to 1 in log models is measured as as $100 \times (e^{\delta} - 1)$, although throughout the paper we use the approximation $100 \times \delta$. The estimated treatment effects are small enough that this approximation is very close to the actual change [48].

manner as state-specific trends in difference-in-differences models that measure the effect of state policies. Including this trend has little affect on the indicator variable estimate, which remains at -0.013 in the linear model.

Given the potential for within-group correlation of the residuals, we report standard errors for several different levels of clustering. We initially cluster at the county-year level, although we find this overstates the precision of the treatment effect considerably. Allowing errors to be correlated over multiple years by clustering at the county level produces much larger standard errors. With county-level clustering, the OLS estimate sans habitat trend is not statistically different from zero, although with the trend the estimate is statistically significant at the five percent level. We also report standard errors adjusted for two-way clustering at the county level and the monthly level, following the method described in Cameron et al. [49]. This method produces standard errors that are essentially identical to those from clustering on counties. For the remainder of the paper, we report standard errors adjusted for clustering at the county level.[9]

There is stronger evidence of a decline in employment when we refine the measure of habitat in a county. Estimates from comparable models using the fraction of land in habitat as the treatment area are reported in the third and fourth columns. Based on the model estimated by OLS, we can say that for a one percentage-point increase in the fraction of habitat, employment changes by approximately -0.026% on average. When the trend is included, this estimate rises modestly to -0.03%. Both effects are statistically significant at the five percent level.

[9] We examined several other clustering strategies but the standard errors were generally the same or smaller than those reported in Table 2. For example, we adjusted for cross-county correlations over time by clustering on groups of counties using NOAA's within-state divisions definition. However, the standard errors were essentially the same as with clustering on the county level (e.g. in the linear model without the habitat trend, the division-level clustered standard error of the treatment effect was 0.009).

The second row contains the results from the PPML estimator. Without the habitat-specific trend, the PPML coefficient is -0.009, which is smaller than the comparable OLS estimate. This estimate is not statistically significantly different from zero. When the trend is added, this effect falls to -0.007 but is estimated with greater precision. As with the OLS estimates, when the habitat definition is changed to the fraction of land the estimate rises several fold compared to the effects reported in the first and second columns, and is highly significant at the one percent level. Again, the effect rises when the trend is included.

Our preferred model includes the habitat-specific trend and is estimated by PPML. While the differences between the OLS and PPML-estimated coefficients are enough to be economically meaningful, regression diagnostics suggest that the exponential specification of the PPML estimator may be more appropriate. Following Santos-Silva and Tenreyro [42], we conducted a heteroskedasticity-robust RESET test. For the model estimated by OLS, the hypothesis of a correct specification was not rejected (p-value = 0.12).[10] However, when we carried out a Park-type regression to test for heteroskedasticity [50, 51], the regression test revealed the conditional variance to be proportional to the mean, but not quite enough to satisfy the strict heteroskedasticity requirements of the log-linear model.[11] Hereafter, we focus on the PPML results but would like to note that, in general, both estimators provide evidence that ESA regulations reduce relative employment in counties with habitat.

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[10] We applied the RESET test to the specification with the time trend. When the test was carried out with the PPML estimator, the hypothesis of a correct specification could not be rejected at the 1% level, although it failed at the 5% (p-value = 0.02). However, the exponential model more easily passed the test when it included a richer set of controls. For example, when state-period effects are included the test yields no evidence of model misspecification (p-value = 0.11).

[11] The regression estimated the model $\ln(\mathrm{Y}_{it} - \hat{\mathrm{Y}}_{it})^2 = \alpha + \beta \ln \hat{\mathrm{Y}}_{it} + \nu_{it}$, where $\hat{\mathrm{Y}}_{it}$ denotes the fitted values of Y_{it}. The OLS estimator of the log-linear model only provides valid information about Y_{it} under the condition $\beta = 2$. We estimate $\beta = 1.6$ (p-value = 0 for a test of $\beta = 2$), so the OLS estimates are in fact biased. However, at least in our application the bias appears to be modest.

Additional controls and state-time effects

We next test the robustness of the results by adding variables for drought, commodity prices and state-specific unobservable transitory factors. The drought index is included because the lesser prairie chicken was listed at a time of extreme drought in the five state region. Negative index values indicate that an area received less than average rainfall in a month. This variable allows us to test if drought in habitat counties drove the decline in employment observed after the ESA listing. Oil and gas prices (with a six month lag) are added to control for their influence in states that disproportionately rely on these commodities. Specifically, the price of oil is interacted with an indicator for Texas and Oklahoma counties, while the price of natural gas is interacted with an indicator for Texas counties. We also include the effect of wheat prices in Kansas, by interacting wheat prices with an indicator for Kansas counties. It is possible that the effect of ESA regulations is confounded by declines in key commodity prices in the states with relatively more habitat (i.e. Kansas, Oklahoma and Texas).

For brevity we report the results only for the model that includes the habitat trend. In general, across the possible specifications and estimators, we find the impacts reported in Table 2 are largely insensitive to additional controls. The revised estimates are in Table 3, which shows that controlling for drought and commodity prices has very little impact on the treatment effect. The coefficient drops slightly from -0.007 to -0.005 when habitat is measured as an indicator, and from -0.029 to -0.024 when habitat is measured as a fraction; the latter is statistically significant at the five percent level. Both estimates and their significance levels are essentially unchanged when state-month dummies are included. We can therefore rule out changes in drought severity, wheat prices, oil prices, natural gas prices and any seasonal factor common to counties within states as influencing the measured treatment effect.

The final specification in Table 3, presented in columns 3 and 6, adds state-period effects to control for all unobserved time-dependent factors (such as a common trend) affecting counties within each state. This specification precludes estimating the commodity price variables and state-month effects, which only vary at the state level. Adding this richer set of controls results in a modestly larger treatment effect, which is statistically significant at least at the five percent level in both specifications. Interestingly, the effect of drought now appears to be zero.

The timing of employment changes

To investigate the timing of employment changes with respect to ESA regulations, we now estimate the treatment effect with several monthly leads and lags. This specification interacts the treatment with dummy variables for each month running from May 2013 to November 2014 and then for the period December 2014 onward.[12] This allows us to examine how the employment trend in habitat counties differed from comparison counties a full year prior to and in the months after the listing. Employers may have anticipated a listing because the FWS made several pre-listing announcements about the status of the lesser prairie chicken. Specifically, in May 2013 the FWS proposed listing the lesser prairie chicken with the 4(d) rule. This proposal was revised in December 2013 to encourage participation in the Range-wide Plan's habitat conservation program.

The estimated leads and lags from the model are plotted in Figure 3, which provides some evidence that employers anticipated a listing, responded to pre-listing

[12]The regression equation is $\mathrm{Y}_{it} = \exp\left[\gamma_i + \tau_t + \sum_{\tau=-12}^{6} \delta_\tau \big(habitat_i \cdot \Phi_\tau\big) + \delta_7 \big(habitat_i \cdot \Phi_7\big) + \beta \mathrm{X}_{it}\right] + \eta_{it}$ where Φ_τ are indicator variables for period τ with $\tau = 0$ in the month of listing, and Φ_7 is an indicator variable the time after $\tau = 7$.

conservation actions, or a combination of the two. The first leading estimates are close to zero, indicating no difference between the habitat and comparison counties in terms of employment growth. Including additional leads does not change the interpetation of the figure, as they are close to zero. No decline in the employment trend is observed after the first major pre-listing announcement by the FWS in May 2013. A notable decline occurs after the December 2013 announcement, without any appearance of a recovery over the next few months. Finally, a substantial and persistent decline occurs after the listing and when ESA regulations went into effect.[13]

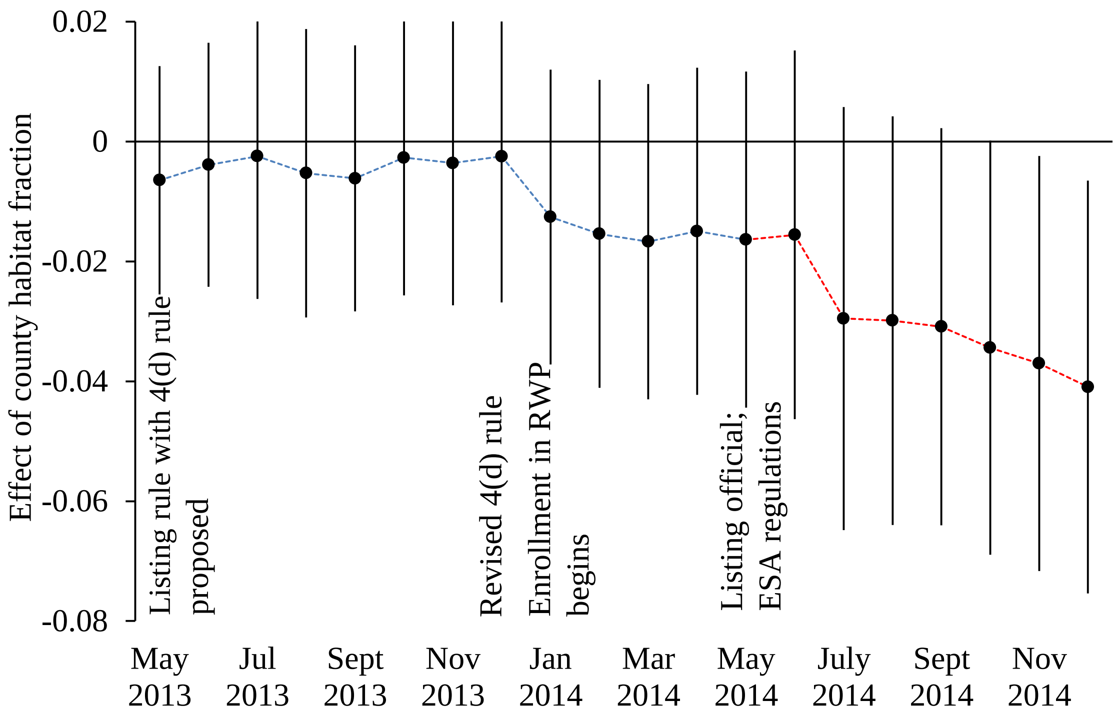

Figure 3: Estimated employment impact of the fraction of land in habitat in the months before and after the lesser prairie chicken was listed as threatened. The vertical bars show 95% confidence intervals.

To statistically measure the effect the December announcement and Range-wide Plan may have had we estimated the model with the habitat variable interacted with

[13]The apparent inertia of about one month in the employment impact observed in the figure may be due to the conditions of existing business contracts.

an indicator for the period following the FWS's announcements about the revised 4(d) rule (and, hence, the start of enrollment in the Range-wide Plan). The results are presented in Table 4. The first column presents the estimates when habitat is measured as an indicator. Note that controlling for the timing of the Range-wide Plan substantially increases the precision of the ESA treatment effect. While the effect of the Range-wide Plan policy is statistically insignificant (in the first regression), the effect of ESA regulations is significant at the ten percent level. When state-period effects are added, the effect of the Range-wide Plan is negative and statistically significant at the five percent level, while the effect of ESA regulations is also negative and significant at the five percent level. The remaining columns repeat these regressions except with habitat measured as a fraction. Note that the effect of ESA regulations reported in columns 3 and 4 attenuates quite a bit compared with estimates described earlier, suggesting that we may be overstating the effect of ESA regulations by ignoring the impacts of pre-listing conservation actions.

These results show that employment in habitat counties declined prior to the ESA listing, and that this decline occured at the time the Range-wide Plan was endorsed by the FWS and began offering WCAs and CCAAs to developers. This may indicate that developer agreements made through the Range-wide Plan encouraged private conservation actions at the cost of established land uses, which subsequently affected employment levels. Unfortunately, with this data and little documentation about particpation rates in the Range-wide Plan's CCAAs, we can not determine whether labor demand was influenced by habitat conservation actions per se prior to the listing. It is also possible that general awareness of the lesser prairie chicken's status fueled speculation among some employers that a listing would eventually occur.

Alternative comparison group

If ESA regulations discourage development, we may be overestimating the employment impact if economic activities that would have occured in the habitat area without the ESA listing move outside the habitat area. The most plausable scenario is that economic activity shifts away from habitat counties toward neighboring counties. Ignoring this spillover would lead us to overstate the impact of ESA regulations, and a more accurate estimate of the treatment effect could be gained by narrowing the comparison group to include only counties that do not buffer the habitat area.

Another potential concern with the benchmark comparison group is many of the comparison counties at one time supported lesser prairie chicken habitat. The fact that these counties no longer provide suitable habitat suggests they may not be appropriate controls for the counties that do. Put differently, latent factors may be driving both habitat loss and employment growth, and counties that no longer support habitat may be experiencing different employment trends. Naturally, counties that have lost their habitat tend to buffer the habitat area.

To address these concerns, we re-estimated the benchmark regressions in which the comparison group excludes counties that once contained lesser prairie chicken habitat. These results are reported in Table 5, where each cell presents an estimate of the treatment effect. For robustness, we also report the estimates from specifications that include state-period effects. The first row shows the results from the original sample, which can be directly compared to the estimates in the second row, which come from the modified sample. Across specifications, there is essentially no change in the effect of ESA regulations when these neighboring counties are dropped.

Overall, these estimates provide little support for the hypothesis that ignoring development spillovers would lead us to overestimate the impact on employment.

The treatment effect hardly budges when ex-habitat counties are omitted, despite the loss of over 3,000 observations (nearly one-third of the sample).

Industry-specific impacts

We conduct an industry-specific analysis to further investigate the impacts of ESA regulations. The industries most likely to be impacted by regulations include construction, agriculture and energy, corresponding to NAICS sectors 23 (construction), 11 (agriculture and forestry) and 21 (mining, oil and natural gas extraction), respectively. The QCEW suppresses county employment data when an industry sector includes only a few establishments in a county, and this explains the notably smaller sample size when we use the data on construction employment. To avoid a similar restriction for natural resource-related employment, our analysis groups agriculture and energy employment into a generic natural resource category, which corresponds to NAICS supersector 10.

Although the industry-level estimates are not always precisely measured, they suggest that impacts may concentrate in certain employment sectors. The results are reported in Table 6. For natural resources-related employment, the coefficients are actually positive in the specifications that measure habitat as an indicator. The sign changes when habitat is measured is a fraction, however none of the estimates for this sector are remotely signficant. In contrast, the estimates for construction-related employment are all negative and larger in magnitude compared with the benchmark estimates. When habitat is measured as a fraction, the effect sizes are large enough to be significant (otherwise, the QCEW's suppression of some of the employment data appears to be taking a toll on the precision of the estimates). Although it is not possible to know at what values the data are truncated, we do notice an increase in the number of missing values in the employment data after the listing, which suggests data suppression to protect establishment confidentiality may be increasing because employment at some establishments is shrinking.

6 Conclusion

This paper presents evidence that ESA regulations negatively affect employment in habitat areas for listed species. Using a difference-in-differences model and panel data on employment, we found counties with more habitat tend to suffer larger employment impacts compared to counties with less habitat. The precise estimate of this effect was somewhat sensitive to the type of estimator we used—in this case, OLS and PPML—but it was always negative.

There is some evidence that pre-listing conservation actions affected employment. Conservation agreements between private developers and wildlife agencies may be designed to reduce the regulatory implications of working on land with an endangered species, but these programs still have an economic cost. The good news is, if declines in employment are attributable to participation in conservation agreements, the private sector is responding to conservation incentives. However, it is also possible that announcements about conservation actions helped employers anticipate a listing. In this case shifts in labor demand may have been temporary and returned to normal if the species had not been listed. This question deserves further study, as many species considered for listing under the ESA never receive threaten or endangered species status.

In our application to the lesser prairie chicken, we estimated a relative employment loss of about 1% in counties with lesser prairie chicken habitat after ESA regulations took effect. Employment in these counties averaged 4400 in the year prior to listing, implying a loss of about 44 jobs per county due to ESA regulations. We also estimated that for every 1% of habitat in a county, ESA regulations reduced overall employment by about 0.025% relative to non-habitat counties. Given the average affected county has 62% of land in habitat, this suggests a loss of about 68 jobs per county. Overall, the total number of jobs lost due to the listing is in the neighborhood of 4,000-6,000. Prior research estimates employment losses due to protections for other species in the tens of thousands [32], so the effect we measure is comparatively modest. Furthermore, our estimate is a relative measure and it is clear overall employment continued to grow in the habitat area after regulations, albeit at a slower pace. At the same time, it is a real economic cost to lose thousands of jobs, especially when those jobs are located in areas with a dearth of local alternatives. We see the evidence in this paper as contributing important empirical data points to the debate on the economic costs of endangered species protection, although both sides of the conservation-versus-jobs debate will likely argue the results here support their side.

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Table 1: Employment means in habitat counties and comparison counties.

Variable	Habitat counties	Comparison counties	Other counties in 5-state region
Total employment	4,218	4,805	44,420
Percent employment in agricultural and natural resource sector	14.8%	13.4%	5.2%
Employment growth between January 2011 and January 2014	4.9%	4.8%	5.2%

Table 2: The effect of ESA regulations on employment in counties with lesser prairie chicken habitat. Each cell presents an estimate of the treatment effect.

Habitat variable:	Post-listing county habitat indicator		Post-listing county habitat fraction	
Estimator	(1)	(2)	(3)	(4)
OLS	-0.013 [0.006] (0.009) ⟨0.009⟩	-0.013 [0.006] (0.006) ⟨0.006⟩	-0.026 [0.007] (0.010) ⟨0.010⟩	-0.030 [0.008] (0.011) ⟨0.011⟩
PPML	-0.008 [0.007] (0.011) ⟨0.012⟩	-0.007 [0.007] (0.005) ⟨0.005⟩	-0.024 [0.008] (0.012) ⟨0.012⟩	-0.029 [0.008] (0.011) ⟨0.011⟩
Habitat-specific trend	No	Yes	No	Yes

The unit of observation is a county in a month. Standard errors computered under various error correlation assumptions are reported below the coefficients. Standard errors adjusted for clustering at the county-year level are reported in square brackets. Standard errors adjusted for clustering at the county level are reported in parentheses. Standard errors adjusted for two-way clustering at the county level and the monthly (period) level are reported in angled brackets. All models include county and period effects. The number of observations is 10,887.

Table 3: The effect of ESA regulations, controlling for drought, commodity prices and unobservable transitory factors specific to states.

Habitat variable:	Post-listing county habitat indicator			Post-listing county habitat fraction		
	(1)	(2)	(3)	(4)	(5)	(6)
ESA regulations	-0.005	-0.005	-0.012***	-0.024**	-0.026**	-0.028**
	(0.004)	(0.004)	(0.004)	(0.010)	(0.010)	(0.012)
Palmer drought index	0.002***	0.003***	0.001	0.002***	0.003***	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Wheat price (KS)	0.013***	0.013***		0.011***	0.011***	
	(0.004)	(0.004)		(0.003)	(0.003)	
Oil price (OK, TX)	0.040**	0.041**		0.040**	0.039**	
	(0.020)	(0.021)		(0.019)	(0.020)	
Natural gas price (OK, TX)	0.001	0.001		0.000	0.001	
	(0.002)	(0.002)		(0.002)	(0.002)	
Habitat-specific trend	Yes	Yes	Yes	Yes	Yes	Yes
State-month effects	No	Yes	N/A	No	Yes	N/A
State-period effects	No	No	Yes	No	No	Yes

*, **, *** denotes significance at the 10%, 5% and 1% level, respectively. Oil price is denominated in 100s of dollars per barrel. All models include county and period effects. Standard errors adjusted for clustering at the county level are listed below the coefficients in parentheses.

Table 4: The effect of ESA regulations and pre-listing announcements.

Habitat variable:	Post-listing county habitat indicator		Post-listing county habitat fraction	
Variable	(1)	(2)	(3)	(4)
Revised 4(d) rule and beginning of RWP enrollment	0.001 (0.005)	-0.011** (0.005)	-0.018* (0.011)	-0.020* (0.011)
ESA regulations	-0.007* (0.004)	-0.008** (0.003)	-0.018*** (0.006)	-0.014** (0.007)
Habitat-specific trend	Yes	Yes	Yes	Yes
State-period effects	No	Yes	No	Yes

*, **, *** denotes significance at the 10%, 5% and 1% level, respectively. All models include county and period effects. Standard errors adjusted for clustering at the county level are listed below the coefficients in parentheses.

Table 5: The effect of ESA regulations, in which the comparison group does not include counties that lost habitat due to development. Each cell presents an estimate of the treatment effect.

Habitat variable:	Post-listing county habitat indicator		Post-listing county habitat fraction	
Comparison group	(1)	(2)	(3)	(4)
Rural grassland counties (benchmark)	-0.007 (0.005)	-0.012*** (0.004)	-0.029** (0.011)	-0.028** (0.012)
Rural grassland counties with no historic habitat	-0.005 (0.006)	-0.009** (0.005)	-0.030** (0.013)	-0.027** (0.013)
Habitat-specific trend	Yes	Yes	Yes	Yes
State-period effects	No	Yes	No	Yes

*, **, *** denotes significance at the 10%, 5% and 1% level, respectively. All models include county and period effects. Standard errors adjusted for clustering at the county level are listed below the coefficients in parentheses. The number of observations is 10,887 for the benchmark sample and 7,410 for the sample that omits counties that lost habitat.

Table 6: The effect of ESA regulations on employment in the construction and natural resources sectors. Each cell presents an estimate of the treatment effect.

Habitat variable:	Post-listing county habitat indicator		Post-listing county habitat fraction	
Industry sector	(1)	(2)	(3)	(4)
Construction	-0.030 (0.037)	-0.043 (0.034)	-0.108** (0.045)	-0.131*** (0.042)
Natural resources	0.009 (0.015)	0.012 (0.016)	-0.030 (0.45)	-0.016 (0.032)
Habitat-specific trend	Yes	Yes	Yes	Yes
State-period effects	No	Yes	No	Yes

*, **, *** denotes significance at the 10%, 5% and 1% level, respectively. All models include county and period effects. Standard errors adjusted for clustering at the county level are listed below the coefficients in parentheses. The number of observations is 7,437 for the construction sample and 10,059 for the natural resources sample.