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Ann E. Ferris

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Environmental regulation can impact local labor markets, potentially reducing incomes and employment and inducing reallocation across sectors. The labor market consequences of environmental regulation are difficult to isolate because regulations frequently apply to large areas, such as the entire United States, and researchers cannot directly observe the counterfactual, in the absence of regulation. I claim that protection of the northern spotted owl in the Pacific Northwest in the 1990s led to an exogenous decline in labor demand in that region. I use this policy change to identify the local and regional impacts of endangered species regulation on employment and incomes in the timber industry. I estimate the local labor market impact of owl protection by comparing counties in the region with and without owl-protected areas. Depending on the choice of control areas and the inclusion of additional control factors, northern spotted owl protection plausibly led to a small loss of incomes and employment in the region

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Ann E. Ferris*

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1 Introduction

The listing of the northern spotted owl as threatened under the Endangered Species Act is widely regarded as one of the most dramatic and controversial environmental regulations in the last 30 years, particularly regarding employment impacts and reserved land areas. The regulation drastically reduced timber harvests on federal forest lands in the Pacific Northwest, leading many to conclude that large declines in timber industry employment in the 1990s were driven primarily by owl protection. Regulation to protect the northern spotted owl, indeed, had potentially the largest localized labor market impact of any U.S. environmental regulation. However, while the literature has focused on estimating the impact of owl protection on the output market for lumber and wood products and an input market: timber harvest, few studies have focused on the link between owl protection and local labor markets.

This paper aims to determine what proportion of the observed declines in timber employment and earnings per worker in the Pacific Northwest and California in the 1990s can be explained by protecting the northern spotted owl. The spotted owl lives in old-growth forest, highly valued by the timber industry. Protecting the spotted owl was a controversial regulation, pitting environmentalists against the timber industry in the 1990s. The impact on local labor markets was projected to be a substantial decline over the following ten years, yet surprisingly few studies have focused on estimating that impact.

The debate over the impacts of protecting the northern spotted owl made its way from state and federal policy and industry spheres into the popular media. Time magazine (Gup 1990) ran a cover story about the owl controversy in June, 1992, during the week when the spotted owl was listed as "threatened" under the Endangered Species Act. The title of the article: "Owl vs. Man". Time magazine stated, based on U.S. Fish and Wildlife's estimates, that the projected impact of cutting timber production by more than 33% on federal forestland in the region would be 30,000 lost timber jobs.

*National Center for Environmental Economics, U.S. Environmental Protection Agency, 1200 Pennsylvania Ave. NW, MC 1809T, Washington, DC 20460. Email: ferris.ann@epa.gov

At the time surrounding the listing of the spotted owl, there were a large number of studies predicting the local economic effects of owl-protection. These predictive estimates of employment declines varied widely, explained by different economic assumptions and political points of view. Goodstein (1999) conducts a review of these estimates. For the direct employment effects of owl protection Goodstein finds that estimates ranged from 21,000 to 87,000 lost jobs in the timber industry, projected over the following decade.

Compared to the plethora of predictive studies, there are relatively few retrospective estimates of the actual employment impacts. The U.S. Forest Service recently produced a 10-year retrospective analysis of the Northwest Forest Plan[1] (Charnley, Donoghue and Stuart 2006). They conclude that 11,400 timber industry jobs were lost from 1990 to 2000 due to owl protection.

This paper's contribution consists of using a more precise measure of local implementation of the regulation: critical habitat areas established under the Endangered Species Act. Spatial data on federal forests and critical habitat areas, where logging was restricted in order to protect the spotted owl, provide a more precise measure of local implementation of the regulation, relative to previous work. Additionally, because critical habitat areas vary in size across counties within the region, this allows for the estimation of the marginal impact on local labor markets of an increase in the size of critical habitat areas.

My identification strategy relies on creating treatment and comparison groups of counties in the region, based on the location of critical habitat areas. I compare these two groups to infer the impact of owl protection on local employment and earnings, both within the timber industry and across other sectors. In addition, by using detailed geographic data on the size of owl protected areas, I am able to estimate the marginal effect of an additional acre of protected area on employment and earnings. Possible spillover effects, where unemployed timber workers may have relocated to other local areas and other sectors, are also considered.

I estimate the overall impact on labor markets in the Pacific Northwest, by comparing changes in employment and earnings between timber-producing counties, both before and after the regulation protecting the spotted owl. Results indicate that timber employment declined by 26 percent, and timber earnings per worker may have declined by 2 percent, from 1990 to 2000. Based on observed levels of timber employment in the region, this implies a loss of 17,600 timber industry jobs due to owl protection. Estimates from a comparison across regions, rather than within the region, imply a loss of 7,700 timber industry jobs.

The next section provides background on the related literature. Section 3 discusses policy aspects of the northern spotted owl controversy in the Pacific Northwest, provides background on the timber industry, and describes critical habitat areas set aside to protect the spotted owl. Section 4 describes the data and outlines my estimation strategy for examining the local labor market impacts of regulation-driven declines in timber harvest. Section 5 focuses on local labor market impacts; employment and earnings effects, and discusses spillover effects. Section 6 describes the labor market impacts when compared to other

[1]The Northwest Forest Plan (NFP) was an agreement outlining a forest management plan for the region, brokered by the Clinton administration in early 1994 (Tuchmann, Connaughton, Freedman and Moriwaki 1996).

regions, particularly the Canadian province of British Columbia, and Section 7 concludes.

2 Related Research

Previous work on estimating the employment impacts of protecting the northern spotted owl has taken varied approaches. The U.S. Forest Service report (Charnley et al. 2006) uses a comparison of rural and urban counties inside the Northwest Forest Plan area, which is composed of the western portions of Washington, Oregon, and Northern California. They estimate a loss of 11,400 timber industry jobs using results from an IMPLAN model[2] with county-level Census data from 1990 and 2000.

Berck, Costello, Fortmann and Hoffmann (2003) focus on timber-dependent counties only in northern California. They estimate economic impacts of spotted owl regulation on local communities, specifically focusing on poverty indicators. In previous work, they present an overview of estimation techniques for employment impacts of environmental policy (Berck and Hoffmann 2002). They present a brief critique of using multiplier models for estimating the impacts of a change in activity level in one industry. Such models necessarily assume a fixed, proportional change in all the inputs used by that industry, not allowing for substitution effects. Freudenburg, Wilson and O'Leary (1998) use a longer time series of timber employment data, back to the 1940s, to estimate the employment impact of spotted owl protection. They compare the most recent declines to those employment declines linked to pre-1990s forest management policy changes. Using state-level data for Oregon and Washington, they conclude that time series breaks prior to 1990, specifically the Wilderness Protection Act of 1964, played a larger role in employment declines than spotted owl regulation, and thus assign spotted owl protection a small role, from a historical perspective.

In terms of the spotted owl, no research has yet to estimate the marginal impacts of an additional acre of critical habitat. Lewis, Hunt and Plantinga (2002) estimate the marginal impact of public forest conservation on employment growth, through mobility, but do so for a different region of the U.S.: the Northern Forest Region (northern Minnesota to Maine). Similarly, I estimate the marginal effect of an additional acre of reserved habitat for the spotted owl.

Within the labor literature examining how local labor markets are impacted by demand shocks, it can generally be difficult to find exogenous variation in labor demand[3]. Bound and Holzer (2000) and Greenstone (2002) look at the U.S. economy as a whole, and construct instruments to identify shifts in demand. Bound and Holzer (2000) use shifts in the composition of major industries in different cities over time. Greenstone (2002) evaluates the impacts of the Clean Air Act amendments on U.S. manufacturing, using variation in

[2]IMPLAN is an input-output multiplier model commonly used by government agencies to estimate regional policy impacts, and was originally developed by the U.S. Forest Service. More information is available at `http://www.implan.com`.

[3]Other spotted owl studies do not directly focus on labor, but do estimate costs (Montgomery, Gardner M. Brown and Adams 1994) and/or welfare changes (Murray and Wear 1998), (Wear and Murray 2004), and (Daigneault and Sohngen 2008).

compliance across counties, driven primarily by air patterns across counties rather than point-source pollution within the county. Greenstone estimates large employment losses for the most polluting manufacturing industries in the entire U.S. over the 1970s and 1980s, due to air pollution regulation.

Other studies rely on observed, reasonably exogenous changes that shift labor demand in certain regions. Black, McKinnish and Sanders (2005) study the impact of the U.S. coal boom and bust periods on local labor markets in Appalachia in the 1970s and 1980s. Treatment counties are defined as those with large amounts of coal reserves. Comparing treatment and comparison counties, they find significant changes in overall mining employment growth and earnings per worker for both the boom and bust periods. They also find significant evidence for spillover effects into employment in other sectors, primarily production of locally-consumed goods such as construction and services. Berman and Bui (2001) examine the impacts of air pollution regulations on industrial employment in Southern California and find no significant employment effects. They also create treatment and comparison groups, over time, region, and industries, and additionally compare their treated region to distant states in the U.S. that have a similar industrial mix, but are not subject to the stricter air pollution regulations in Southern California.

There is no consensus yet on the employment effects of environmental regulation. Most studies appear to find no measurable employment effects, but estimates can vary greatly by the focus and scope of the study. For example, in estimating the impacts of the Clean Air Act amendments on manufacturing employment, these studies find very different estimates whether they focus on the entire U.S. over decades (Greenstone 2002), or for a period of years within one region (Berman and Bui 2001). In comparison to these approaches, I study a specific labor-intesive industry, perhaps providing the best chance of finding measurable employment impacts.

3 Preliminary Considerations

3.1 Policy Background

The northern spotted owl resides in old-growth forest areas of the Northwestern U.S., specifically western Washington and Oregon, and parts of northern California. Observers began to notice the relative scarcity of spotted owls in the 1970s. After several disagreements in the 1980s between environmental groups and the timber industry over federal forest management, a 1989 lawsuit by environmental groups led to an injunction against federal timber sales[4] in Washington and Oregon (Hoberg 2003). With the injunction still in place, the northern spotted owl was listed as "threatened" under the Endangered Species Act on June 26, 1990 (Yaffee 1994). Another legal injunction went into effect in 1991, restricting 10 million acres in 17 National Forests across Washington, Oregon, and California, thereby bringing federal logging in the region to a virtual standstill (Hoberg 2003).

[4]See (Athey, Levin and Seira 2008) for an in-depth explanation of federal timber sales and auctions.

After the spotted owl was listed in 1990, it took a few more years of discussion and compromise to establish protected areas for the owl where timber harvesting would be no longer be allowed. Critical habitat areas were designated on federal forestland by the U.S. Fish and Wildlife Service on January 15, 1992. The critical habitat areas include 2.2 million acres in Washington, 3.3 million acres in Oregon, and 1.4 million acres in northern California (Fed 1990). See Figure 1 for the distribution of the nearly 6.9 million acres of protected publicly-owned forestland. There is substantial variation in the size of critical habitat areas across counties and labor market regions in these three states. Critical habitat areas are only located on public forest land, but the majority of timber land in this region is publicly-owned. In the Pacific Northwest, half of the land area is forest land, and 80% of that is timber land, i.e. capable of producing commerical amounts of lumber. Sixty percent of the forest land in the Pacific Northwest is publicly-owned, either federal, state or local (Smith, Miles, Vissage and Pugh 2002).

Responding to the escalating tensions between environmentalists and industry, the Clinton administration held a town-hall meeting on April 2, 1993, in Portland, Oregon. President Clinton, Vice-President Gore and other aids spent an entire day listening to concerned parties (Hoberg 2003). A year later, in April 1994, the administration presented its policy solution: the Northwest Forest Plan. The plan became the cornerstone for conserving the northern spotted owl on 24.4 million acres of federal land in Oregon, Washington and California (Tuchmann et al. 1996).

The impact on timber harvests in the late 1980s and early 1990s was dramatic. Between 1988 and 1996, timber harvests fell 87 percent on national forests and 38 percent overall in the region (Daniels 2005). See Figure 2 for the declines in timber harvest from both public and private forests.

3.2 Industry Overview

The timber industry in Oregon, Washington, and California is a major supplier for the national market in lumber and wood products. In 1997, these three states alone produced twenty percent of GDP in the timber industry[5]. Timber-related jobs and income can be divided into two manufacturing sectors. The first sector includes industries that manufacture solid wood products. These industries are included in the Standard Industrial Classification under SIC 24. The second sector includes pulp and paper industries, and are included in SIC 26. The primary-processing industries in the solid-wood products sector are logging and logging contractors; sawmill, veneer and plywood mills; hardwood dimension and flooring mills; and special-product sawmills.

The output market considered here, referred to as the timber industry, is the Lumber and Wood Products industry, classified by the Bureau of Economic Analysis during the 1980s and 1990s as SIC 24[6]. The industry includes establishments engaged in cutting timber and pulpwood; sawmills, planing mills, and panel board mills engaged in producing lumber

[5]author's calculations, 1997 state-level GDP from BEA for SIC 24: Logging and Wood Products.

[6]`http://www.bea.gov/regional/definitions/nextpage.cfm?key=Lumber and wood products`

and wood basic materials; and establishments engaged in manufacturing finished articles made entirely or mainly of wood or related materials. Prior empirical research characterizes Lumber and Wood Products as a national industry (Wear and Murray 2004). However, factor markets are regarded as regional in scope, due to transaction costs. Here, inputs are capital, labor, and timber harvest (stumpage) (Daigneault and Sohngen 2008).

Total observed loss in timber employment in the Northwest Forest Plan area, from 1990 to 2000, was 30,000 jobs (Charnley et al. 2006). This includes the western parts of Oregon, Washington, and northern California, where forestry was vitally important to the local, rural economies. See Table 1 for a listing of counties in western Oregon, Washington, and northern California with measures of employment dependency on the timber industry. In some counties, timber employment in 1975[7] was greater than 5% of total employment. Some of those counties are: Clallam, Cowlitz, Grays Harbor, Klickitat, Lewis and Mason counties in Washington; Coos, Curry, Douglas, Klamath, Linn, and Polk counties in Oregon; and Del Norte County in California. In these forestry-dependent counties, timber industry earnings also made up a significant porportion of overall earnings, as listed in Table 1.

4 Data and Estimation Strategy

For information on timber industry employment and earnings in Oregon, Washington and California, I use annual county-level data for SIC 24: Lumber and Wood Products, available from the Bureau of Labor Statistics (BLS) for 1975 to 2000. The data is from the Quarterly Census of Employment and Wages; formerly ES-202, an establishment census, available on the BLS website. This dataset is a panel of establishments, and does not contain information on individual workers. In the establishment-level data, which is primarily collected for unemployment insurance purposes, a timber company may have their administrative office located in a different county from where all their logging takes place, and where the workers reside. Employment reports are for the county where the office is located. Consider a scenario where the company has logging operations in a county that has a some owl critical habitat area, but the administrative office is located in a different county. Then a measure of timber employment change due to owl protection using a county-level indicator for critical habitat areas will not capture the employment change as reported by the company's administrative office, and will be biased downwards. Employment will be reported as decreased, but only in the county *next* to the county with the owl protected area, where the administrative office is located. Therefore the indicator variable for owl protected areas may not produce any changes in estimated employment, using this identification strategy, if the administrative office is not in the same county as the protected area.

In addition to using county-level information to estimate the employment and earnings effects of owl-protection, I also perform a regional comparison. For regional employment and earnings data, I use U.S. Census data from the IPUMS, 1990 and 2000 five-percent surveys. These data allow observation of long-term changes, over 10 years. The most detailed level

[7]The first year of available data for this study. See Section 3 for further explanation.

of geography in the census data are Public Use Microdata Areas (PUMAs), groupings of 100,000+ residents, for the Pacific Northwest and California. I use the regional level employment data to compare the timber industry declines with declines in British Columbia, a Canadian province located just north of the Pacific Northwest. Data for timber employment in British Columbia are available from the Canadian Labor Force Survey, collected by Statistics Canada.[8]

4.1 Critical Habitat Areas

I use spatial data on the critical habitat areas, established in January 1992, in order to create two new measures of local implementation of owl-protection regulation. The first measure is a county-level indicator for whether or not any critical habitat areas were established in 1992. Forty-eight counties out of a total of 133 counties in Oregon, Washington, and California have some areas of owl critical habitat, which prevented logging on public forest lands. Figure 3 shows these 48 treatment counties in the region[9], concentrated in western Oregon and Washington and northern California, and the 52 counties selected as a comparison group. The comparison counties all have some amount of publicly-owned timberland and some amount of timber industry employment, over the time period studied. See Figure 3 for a map of the Pacific Northwest and California showing the treatment and comparison counties. Data on National Forest and publicly-owned timberland areas in the Pacific Northwest is available through the U.S. Forest Service website[10].

Additionally, I estimate the marginal effect of increases in the area of owl protection, measured in acres[11]. I use spatial data on the locations of these owl critical habitat areas in the Pacific Northwest, from the Regional Ecosystem Office[12], which provides support for the Northwest Forest Plan. The establishment of owl critical habitat areas in 1992 covered 6.9 million acres of publicly-owed forest land, both National Forest and Bureau of Land Management areas, spread over Oregon, Washington, and northern California. For those counties with protected areas, the average area preserved for the spotted owl was 153,000 acres, and ranged from 7,000 acres to a maximum amount of 787,000 acres. Additionally, critical habitat areas could only be placed on publicly owned land, so I include county-level measures of both public and privately owned timberland areas in the empirical specifications. These county-level measures of timberland, both public and private, are from the pre-1990 time period, and are therefore not changing over my sample.

Previous, similar studies have not taken advantage of this level of geographic detail and have instead relied upon, e.g., an indicator for rural counties (Charnley et al. 2006) as a proxy for relative concentrations of timber employment, or state-level measures (Freudenburg et

[8]Statistics Canada data series is available through the British Columbia government's website: `http://www.bcstats.gov.bc.ca/data/lss/labour.asp`.

[9]See Table 1 for a complete listing of these treatment counties

[10]U.S. Forest Service: `http://svinetfc4.fs.fed.us/clearinghouse/index.html`.

[11]Analyses using critical habitat areas as a fraction of public forest land in the county produce similar results.

[12]REO GIS data website: `http://www.reo.gov/gis/data/gisdata/`.

al. 1998). The two measures used in this paper more precisely measure the implementation of the regulation, at a local level. This preciseness in measuring the regulation's implementation allows the use of variation in the location and size of owl-protected areas to identify declines in timber employment and earnings linked to owl protection.

4.2 Estimation Strategy

If timber industry workers are relatively immobile and therefore counties are reasonable estimates of geography for local labor markets, then we expect to see a decline in timber employment and earnings in treatment counties, which have owl-protected areas, relative to comparison counties. Considering the theory of labor market supply and demand, a decrease in labor demand while labor supply stays constant leads to a decrease in both employment and wages. Both timber and labor are inputs to the production of lumber and wood products. A decline in timber harvest due to regulations restricts the supply of timber as an input. This can lead to a decline in labor demand, if the output effect is larger than the substitution effect. Previous research has found that labor and timber are relative substitutes, but their elasticity of substitution is relatively small (Vincent, Lange and Seok 1992). It is reasonable to expect that for such a large negative shock in timber harvest, the output effect will dominate the substitution effect, and we expect a decline in labor demand. To test this empirically, I expect to find a decline in both employment and wages in the timber industry, in counties with owl-protected areas.

Table 2 reports the difference in annual growth in total employment and earnings per worker for treatment counties before and after the owl regulation. Treatment counties are those which had owl critical habitat areas established in 1992. The first row of Table 2 shows that the average level of timber industry employment, per county, fell markedly after 1990. From 1975-1989, before owl regulation, the average treatment county had 2,391 timber workers. That number fell, from 1990 to 2000, to an average of 1,846 timber workers. Timber employment shows negative growth for both time periods, however the decline was larger after owl-protection. The growth rate in timber earnings by county was positive prior to 1990, but fell to a zero growth rate afterwards. Finally, timber earnings per worker grew at a 5% rate from 1975-1989 in treatment counties, but fell from 1990 to 2000 to a 3% rate.

Table 3 presents before-and-after estimates for 1990, for treatment and comparison counties separately. The time period covered by the county-level data is 1975 to 2000, in annual averages. Pooled OLS coefficients are presented in Table 3, with the top half of the table showing, for treatment counties, estimates of the percentage decline in timber employment. The indicator for owl regulation, $post - 1990$, shows a range of declines, over eight statistically-significant specifications, from 28 to 32 percent declines in timber employment from 1991-2000 compared to 1975-1990. The simple difference in means: pre- and post-owl regulation is a decline of 32 percent, and is listed in column (1). Taking the average across counties, the difference between pre- and post-owl regulation employment is a decline of 27.6 percent, shown in column (2), and is statistically significant at the 1-percent level. The final specification with both county indicators and measures of the area of publicly-owned and privately-owned timberland in each county shows a statistically significant decline of

29.3 percent (column 8). Over the same time period and same specifications the decline in comparison counties ranges from -0.135, in column (4), to -0.009 in column (5); though none are precise enough to be statistically significant at even a ten percent level. Columns (4) and (6) - (8) include measures of the acreage of public and private timberland in the county, to control for observable characteristics that influenced the location of owl critical habitat areas and therefore classification here into treatment or comparison counties. Inclusion of timberland acreage brings the estimate for treatment counties to a decline of 29 percent, while for comparison counties, it is an imprecisely estimated 3 percent decrease in timber employment.

I use difference-in-differences estimation to assess the effect of owl habitat reserves on labor market outcomes. Variation in the location and size of owl-protected areas helps to identify the impact on timber industry employment and earnings in the Pacific Northwest and California. I compare timber employment and earnings in counties with owl-protected areas relative to counties without owl-protection, before and after 1990, when the regulation was implemented.

To estimate the decline in timber industry employment and earnings per worker that could be attributed to owl-protection, I use the following difference-in-differences (DD) specification:

$$\ln Y_{ct} = \alpha + \delta(\text{post-1990})(\text{owl}) + \gamma_c + \lambda_t + \epsilon_{ct}, \quad (1)$$

where Y_{ct} is timber employment or earnings per worker for county c in year t. (*owl*) is an identifier for treatment counties. *post*-1990 takes the value of 1 for the years 1990 to 2000, and 0 for earlier years, back to 1975. The coefficient of interest is δ, which is the difference-in-differences estimate of the change in $ln(Y)$ due to treatment, and measures the semi-elasticity of labor demand and owl regulation. γ_c and λ_t are county and year indicators, included in a range of specifications. Additional county-level controls include measures of timberland acreage in each county, both privately and publicly-owned; an observable difference in the characteristics of counties that may have played a part in determining selection for critical habitat areas.

To estimate the marginal effect of an increase in the size of critical habitat areas, I utilize a specification similar to the above, but incorporating non-linearities in the size of owl-protected areas for ease of interpretation:

$$\begin{aligned} \ln Y_{ct} = {} & \alpha + \delta_1(\text{post-1990})(\ln(\text{owl acres})) \\ & + \delta_2((\text{post-1990})(\ln(\text{owl acres}))^2 + \lambda_t \\ & + \beta_4 \ln(\text{owl acres}) + \beta_5(\ln(\text{owl acres}))^2 + \epsilon_{ct}, \end{aligned} \quad (2)$$

where *ln(owl acres)* identifies amounts of owl-protected habitat, and is differenced from the mean for ease of interpretation. δ_1 is directly interpreted as the marginal effect on timber employment of an increase in owl-protected habitat.

In addition to the restrictions on timber harvesting due to the spotted owl, a number of other factors were at play in terms of declining timber employment in the Pacific Northwest.

Some of these confounding factors are: the recession in the early 1990s, the decline in demand for timber exports to Asian countries, restrictions on Canadian imports of timber and lumber, the shift towards more capital-intensive production, particularly in sawmills, and the shift in production away from the Pacific Northwest into the southern U.S.

The industry is very cyclical, and demand for lumber and wood products generally follows the business cycle (Wear and Murray 2004). The recession in the early 1990s was driven, in part, by the housing market. The slowdown impacted demand for lumber and wood products. Production costs, perhaps driven by the restriction of timber supply related to owl protection, led to a shift in industry production from the Pacific Northwest to the U.S. Southeast (Abt 1987), (Smith and Munn 1998), (Wear and Murray 2004), (Daigneault and Sohngen 2008). At around this time, in the 1970s and 1980s, there was also an industry-wide shift towards more capital-intensive production (Abt 1987).

Within the Pacific Northwest and California region, groupings of treatment and comparison counties are arguably subject to the same macroeconomic forces. Both should be equally affected by the cyclicality of housing starts and therefore demand changes for lumber and wood products, Canadian tariffs, and a general shift in federal timber policy towards more recreation and less timber production. If both groups have the same reactions, over time, to these factors but differ only in the implementation of spotted owl regulation, then the difference-in-differences estimator, δ, is appropriate and will capture the average effects on employment and earnings per worker. Specifically, the key identifying assumption is that timber employment trends would be the same in both the treatment and comparison county groups if there had been no owl-protection. If there were different trends over time, they would be confounded with any changes due to spotted owl regulation, and the difference-in-differences estimator would no longer capture the effect of the regulation alone.

In the next section, I present results that use variation in critical habitat areas within the Pacific Northwest and California to identify the declines in timber employment and earnings due to spotted owl-protection. The accuracy of this approach depends on the assumption that both the treatment and comparison counties in the region were equally impacted by the confounding factors listed above. To further explore the limits of this assumption, later in Section 5 I use a measure of regional employment, grouping together both treatment and comparison counties in the Pacific Northwest. I then compare changes in that measure to changes in timber employment in a nearby region: the Canadian province of British Columbia.

5 Local Labor Market Impacts

In this section, I investigate the local labor market impacts of the owl regulations. Protecting the spotted owl reduced timber harvests in federal forests with owl-protected areas, and therefore presumably reduced demand for timber workers as well.

All else equal, a decline in timber harvests should imply, through supply and demand theory, a decline in both employment and earnings in the labor market for timber workers. If workers are relatively immobile and counties are therefore reasonable estimates of geography

for local labor markets, we can expect to see a decline in timber employment and earnings in treatment counties, relative to comparison counties.

5.1 Employment Effects

The top panel of Figure 4 shows timber employment, from 1975 to 2000, for both groups: treatment and comparison counties. Notice that timber employment in treatment counties, i.e. those with some critical habitat areas, is always greater than in comparison counties. Both series exhibit similar sensitivity to the business cycle, with declines in the recessions of the early 1980s and 1990s.

Table 4 presents difference-in-differences (DD) estimates for the natural log of timber employment using a range of sample sizes and specifications: pooled OLS for 1975-2000 combined with controls for amounts of timberland in each county and county and year indicators. Column (1), with four observations, shows the differences in the means between treatment and comparison counties, pre- and post-1990. The coefficient on $(post-1990*owl)$ is fairly robust across the specifications in Table 4 and estimated at -0.261 in the specification with the full set of indicators and timberland controls, in column (9). This indicates that timber employment in treatment counties declined by approximately 26 percent relative to comparison counties, from 1990 to 2000 as compared to 1975-1989. Average timber employment in a treatment county was 1,412 in the pre-owl-protection period (1975-1989), so this percent decline implies a loss of 368 timber jobs in the average county. To calculate the decline in total timber employment in treatment counties multiply the average number of jobs, 368, by the number of treatment counties, 48, implying an overall employment decline of approximately 17,600 timber jobs from 1990 to 2000.

The marginal effects of an additional acre of owl-protected area on timber employment, as specified in Section 3 can be estimated using acres of owl-protected areas, by county, for the treatment counties. Estimates of the marginal effect of an increase in the size of critical habitat areas on timber employment, measured as the natural log, are presented in Table 5. The first two rows report pooled OLS coefficients for a non-linear specification of $ln(owl\ acres)$ interacted with the policy dummy, $post-1990$, presented as differences from the mean, for ease of interpretation. Instead of summing the linear coefficient with twice the quadratic term, the estimate reported in the top row, because of this transformation, is the marginal effect. I present estimates for eight specifications: pooled OLS, pooled OLS with controls for amounts of timberland in each county, and year and county indicators. The coefficient on $(post-1990*ln(owlacres))$, the marginal effect of an additional acre of owl-protected area, is robust across specifications, ranging from -0.11 to -0.06 and is estimated at -0.09 in the specification with timberland areas, and year and county indicators, in column (8). The interpretation of the marginal effect is a 0.09 percent decrease in timber employment for a one percent increase in *owl acres*. The average amount of owl-protected area, by county, in the group of treatment counties, is 153,000 acres. The average county with owl-protected area has a negative association between increased owl-protected areas, in terms of size within the county, and timber employment.

5.2 Earnings Effects

Table 6 presents the same approach and methodology as in Table 4, estimating equation 2.1, but for a different outcome variable: earnings per worker, in the timber industry. The coefficient of interest is consistently, but imprecisely, estimated as a decline of about 2 percent, ranging only from -1.3 to -3.7 percent across nine specifications. This implies a decline of 2 percent in timber industry earnings per worker, from 1990 to 2000. In the BLS data, the information available is the number of workers by industry and county, reported monthly, and the total compensation paid during the quarter. In this study, I use annual averages of both number of workers and total compensation, i.e. earnings. Because of data limitations, total compensation cannot be decomposed into hours and wages.

5.3 Spillover Effects

One serious concern with this research design and this particular policy, is that the regulation to protect the spotted owl may have also negatively impacted industries besides the timber industry and impacted other nearby counties that did not have critical habitat areas. We can classify these indirect effects of the regulation as either sectoral spillovers or geographic spillovers. Sectoral spillovers would consist of unemployed timber workers who remain in their county but find new work in a non-timber industry. Geographic spillovers would involve newly unemployed timber workers moving to nearby counties that don't have owl-protected areas in order to find work in the timber industry. If such mobility was occurring, then the estimates from the previous section would be biased, because the group of comparison counties was also indirectly "treated" by the owl regulation.

For illustrative purposes, first assume that there are no sectoral spillover effects. If so, changes in employment in non-timber industries in both treatment and comparison counties would be a good counterfactual for changes in timber employment, in terms of owl-protection. That is, if the spotted owl hadn't been protected and critical habitat areas weren't established, we would expect timber employment and earnings growth in the region to behave similarly to that of non-timber employment and earnings. In this setting, the difference-in-differences estimator, described in equation 2.1, will capture the impact of the treatment without bias.

If there are no spillover effects, and the comparison counties are not impacted by the owl regulations and local labor markets are defined by county boundaries, then we should see no change in timber harvests, employment or earnings, in the comparison counties. This would be a straight-forward partial equilbrium story, where owl-regulation only impacts one market. However, there is a real possibility of spillover effects, particularly into other sectors in the region. Of concern are also geographic spillover effects, where the timber industry increased production outside of areas with owl-protection. If labor markets are linked across counties, we would expect earnings per worker to fall. And if unemployed timber workers look for work in comparison counties, we expect to see timber harvests increase relatively, as well as timber employment.

The next set of results uses comparisons between the timber industry and non-timber

industry (i.e. total employment minus timber employment in each county) to draw comparisons of labor market impacts within the region. Table 7 presents estimates similar to those in Table 4, but for non-timber industries instead of the timber industry. Assuming there are no spillover effects between sectors, we would expect to see no significant difference in non-timber industry employment and earnings per worker before and after 1990. Coefficients in Table 7 are close to zero, with some slightly positive and mostly slightly negative, but none are statistically significant among the nine specifications. The final specification, in column (9) implies a 0.5 percent increase in non-timber employment in treatment counties, but this is not statistically different from zero.

The counterfactual experiment for non-timber earnings per worker, however, leads to significant declines in earnings per worker, for non-timber employees. In Table 8, the estimated relative decline of 5 percent is statistically significant and robust across all nine specifications. One explanation for this effect on earnings would be that if job loss among timber workers caused them to search for work in non-timber industries, this may have increased the labor supply in treatment counties for non-timber industries. If labor demand for non-timber employees is relatively inelastic then such a shift would result in a negligible effect on non-timber employment, but a decline in average earnings per timber worker.

Finally, Tables 9 and 10 present triple difference estimates (DDD) of labor market impacts on employment and earnings per worker using three sources of variation: over time, i.e. pre- and post-1990, between treatment and comparison counties, and comparing timber and non-timber industries. These DDD estimates use three types of comparison groupings to control for as much unobserved variation as possible, and if the treatment counties are well-specified, would leave only the difference due to treatment, in this case, owl protection. As before, with the difference-in-differences estimation, to identify the impact of owl protection alone, we assume that other differences between groups do not vary over time. In Table 9, the coefficient of interest, $(post\text{-}1990 * timber * owl = 1)$, the estimate for timber employment in treatment counties after 1990, is fairly robust across nine specifications, and in column (9) is estimated as a decline of 29.5 percent. Due to the decline in non-timber earnings in treatment counties relative to comparison counties, in Table 10 the DDD estimate for earnings per worker is 3.8 percent and positive, though not statically significant in any specification.

As workers leave their jobs in the timber industry, due to a decrease in timber harvest in the region, they can either stay in unemployment (not measured in the BLS data), drop out of the labor force (e.g. transition to retirement or school), move out of the region (e.g. to the South), or shift to employment in another local sector (e.g. wholesale trade or services). In the final case, this shift in workers will impact the equilibrium wage and employment in non-timber sectors in local, comparison areas. There is some evidence of movement of timber industry workers, specifically using unemployment insurance records to track individuals as they find new work in other sectors (Helvoigt, Adams and Ayre 2003). As in the literature on union wage effects, spillover effects are estimated by looking at the correlation between unionization rates and non-union wages in each local labor market. If the correlation is negative, so non-union wages are lower in markets with higher unionization rates, spillover

effects dominate threat effects. In this spotted owl setting, if non-timber wages are lower and employment is higher in local labor market areas that have higher amounts of owl-protection, then spillover effects exist and can potentially be estimated.

How much is due to geographic spillover effects, *i.e.* timber workers in counties with owl protected areas, losing their jobs and taking new jobs in a comparison county? Either they commute farther to work or they move to a county further away, but still in the Pacific Northwest region. If geographic spillovers are large, we can expect to see increased timber production in comparison counties relative to treatment counties. Indeed, timber production did not decrease as much in comparison counties, relative to treatment counties. Estimation results in Table 11 indicate that timber harvest overall declined by 63 percent in treatment counties, from 1990-2000, relative to 1975-1989 timber production. For comparison counties, the point estimate is a 14 percent increase, which fits the geographic spillover story, though it is not statistically significant. In both groups of counties, public timber harvest declined dramatically.

Another potentially confounding factor is a recessionary effect which may have additionally contributed to further declines in timber employment in treatment counties. As mentioned earlier, the timber industry is cyclically sensitive, and if treatment counties are relatively more sensitive to business cycle effects, these estimates of employment declines beginning in 1990 may be overly large, once any recessionary-effects are considered. Table 12 presents results from timber employment specifications used previously, but only for data *before* owl regulation, so 1975-1989. I rely on the 1981 and 1982 recessions to identify a relative decline in timber employment in treatment counties. Coefficients on the difference-in-differences indicator, $owl * 1980 - 82$, are mostly positive with one negative coefficient in column (7), and only three specifications are statistically significant. The final specification, in column (9), with year and county indicators and measures of county timberland area implies that timber employment increased by 9.5 percent in treatment counties relative to comparison counties, during the 1981-82 recession. Comparing these results for the early 1980s recession, in pre-owl regulation years (1975-1989) to similar specifications in Table 4, in the 1908s recession treatment counties did not experience a noticeable decline in timber employment relative to declines in comparison counties, and may have even seen a slight increase. Therefore, it appears that the cyclicality of timber employment is not a confounding factor for estimates of the labor market impact of spotted owl protection.

6 Labor Market Impacts Across Regions

The regulation that established owl-protected areas, primarily in valuable, old-growth forests, may have been restrictive enough to have had impacts beyond the Pacific Northwest and California. The prior section examined local labor market impacts, assuming that the regulation's effects were contained within the region. However, restrictions on federal timber harvest may have been large enough to induce increased production outside of the Pacific Northwest, with relocation or expansion of firms into other timber-producing regions, such as the southern U.S.

The methodology of using treatment and comparison groups assumes that the treatment group embodies all of the regulation's effects, while the comparison group does not. While this framework fits well with partial equilibrium changes, where the regulation affects a single market, in order to consider the possibility that owl protection had impacts outside of the Pacific Northwest, we must adapt this framework to potentially address general equilibrium changes.

A number of papers have found that declines in timber harvest in the Pacific Northwest led the timber industry to shift towards increased production in the southern states, for example: (Wear and Murray 2004), (Daigneault and Sohngen 2008), and (Smith and Munn 1998). Data on employment in the timber industry support this assertion; there is a marked increase in timber employment growth in southern states beginning in 1990.

Searching for appropriate comparison regions for both the treatment counties in the Pacific Northwest, defined as having some owl-protected areas, and for comparison counties as well, implies that timber employment in comparison regions should be highly correlated before the owl regulation, in 1990. I consider a number of alternative timber-producing regions in the U.S. and I also consider timber employment in British Columbia, Canada.

Correlation coefficients for counties in the Pacific Northwest with owl-protected areas, compared to other regions in the U.S. and the Canadian province British Columbia, are highest for British Columbia (0.66), with the time series shown in the bottom panel of Figure 4. An estimate of overall timber employment effects in the Pacific Northwest and California, when compared to timber employment in British Columbia, is 7,700 lost jobs[13]. This is substantially smaller than the estimate relying on comparison counties *within* the region (17,600 timber jobs), which is potentially subject to geographic spillovers across county groups. British Columbia may be a better comparison, in terms of limited geographic spillovers, because of the larger barriers to movement across an international border, but similarities in both regions' timber industries.

7 Conclusion

In this paper I use spatial data on northern spotted owl critical habitat areas to distinguish counties within the Pacific Northwest that were directly affected by the Endangered Species Act regulation in 1990, from those counties without owl-protected areas. Approximately 7 million acres of publicly-owned forest land was set aside as owl-protected areas in 1992, and the regulation prevented logging in theses areas. Comparisons of timber employment and earnings per worker in these treated counties, relative to comparison counties within the region between 1975 and 2000, both before and after the regulation in 1990, lead to estimates of declines of 26 percent in timber employment and 2 percent in timber earnings per worker. The variation in size of owl-protected areas by county allows me to estimate the marginal effect of an increase in owl-protected area: I find that for a one percent increase in owl-protected area, by county, we should expect a 0.09 percent decline in timber employment,

[13]Regression result from same specification as in Table 4, but in levels and with entire Pacific Northwest and California as "treatment" group with British Columbia as comparison group.

evaluated at the average size of owl-protected acres. These estimates indicate that the local labor market impacts, for the timber industry, were negative, as expected with a decline in labor demand for the timber industry, but not as large in retrospect, as some predictions had suggested.

Analyses of spillover effects, both geographic, for comparison counties in the region, and sectoral, as unemployed timber workers may have taken jobs in other industries within the same counties that have owl-protected areas yield mixed evidence. While employment changes in comparison counties and non-timber industries in treatment counties are not different from zero, earnings per worker in non-timber industries in treatment counties declined by 5 percent, over 1990 to 2000. Robustness checks include estimates of the impacts across non-timber industries, and across other regions of the U.S. and British Columbia. Taken together, these results indicated that Northern Spotted Owl protection plausibly led to a small loss of timber earnings per worker and employment in the Pacific Northwest, with larger declines for counties with larger areas of owl-protection.

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Table 1: **Treatment Counties, Timber Industry (1975)**

County	Timber Employment	Fraction of All Emp.	Fraction of All Earnings
Colusa County, CA	-	-	-
Del Norte County, CA	1,461	0.105	0.129
Glenn County, CA	113	0.007	0.011
Humboldt County, CA	6,520	0.057	0.073
Lake County, CA	80	0.006	0.006
Mendocino County, CA	3,131	0.058	0.081
Shasta County, CA	2,540	0.029	0.036
Siskiyou County, CA	1,946	0.057	0.080
Tehama County, CA	1,167	0.048	0.065
Trinity County, CA	0	0	0
Benton County, OR	1,412	0.022	0.028
Clackamas County, OR	2,236	0.014	0.017
Coos County, OR	4,506	0.065	0.083
Curry County, OR	1,118	0.078	0.116
Deschutes County, OR	2,150	0.042	0.054
Douglas County, OR	8,178	0.081	0.101
Hood River County, OR	630	0.034	0.051
Jackson County, OR	4,662	0.037	0.048
Jefferson County, OR	478	0.044	0.061
Josephine County, OR	2,123	0.050	0.067
Klamath County, OR	4,083	0.065	0.087
Lane County, OR	12,994	0.044	0.056
Lincoln County, OR	774	0.025	0.035
Linn County, OR	5,262	0.054	0.064

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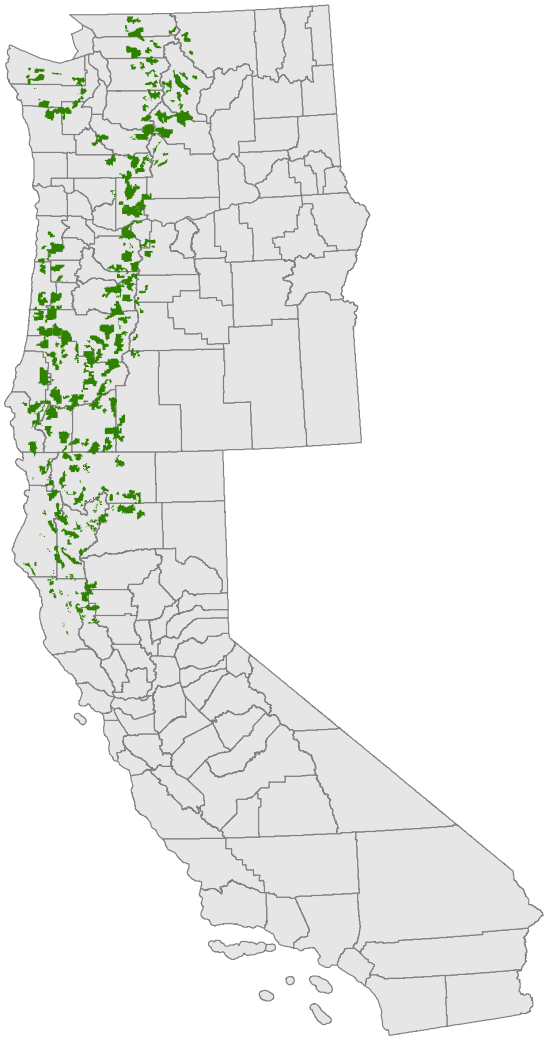
... Table 1 continued

County	Timber Employment	Fraction of All Emp.	Fraction of All Earnings
Marion County, OR	1,654	0.007	0.008
Multnomah County, OR	3,888	0.003	0.004
Polk County, OR	1,515	0.051	0.067
Tillamook County, OR	767	0.047	0.072
Wasco County, OR	420	0.018	0.023
Yamhill County, OR	1,472	0.034	0.045
Chelan County, WA	716	0.012	0.014
Clallam County, WA	2,375	0.057	0.074
Cowlitz County, WA	5,987	0.061	0.068
Grays Harbor County, WA	4,437	0.069	0.082
Jefferson County, WA	253	0.030	0.041
King County, WA	5,698	0.003	0.004
Kittitas County, WA	185	0.009	0.011
Klickitat County, WA	701	0.071	0.088
Lewis County, WA	3,340	0.063	0.084
Mason County, WA	1,522	0.084	0.107
Okanogan County, WA	1,187	0.045	0.054
Pierce County, WA	4,652	0.012	0.015
Skagit County, WA	1,166	0.022	0.027
Skamania County, WA	682	0.129	0.144
Snohomish County, WA	4,269	0.019	0.021
Thurston County, WA	1,095	0.010	0.010
Whatcom County, WA	609	0.006	0.007
Yakima County, WA	1,546	0.010	0.014

Source: BLS Quarterly Census of Employment and Wages, county annual averages, 1975, for OR, WA and CA. (N=133 counties)

Note: Treatment counties had some owl-protected areas, 1992-2000. (N= 48)

Figure 1: **Map of Owl Critical Habitat in the Pacific Northwest and California**



Source: REO GIS data for 1992 critical habitat areas for the northern spotted owl. Darker, green areas are owl critical habitat. County boundaries for Oregon, Washington and California.

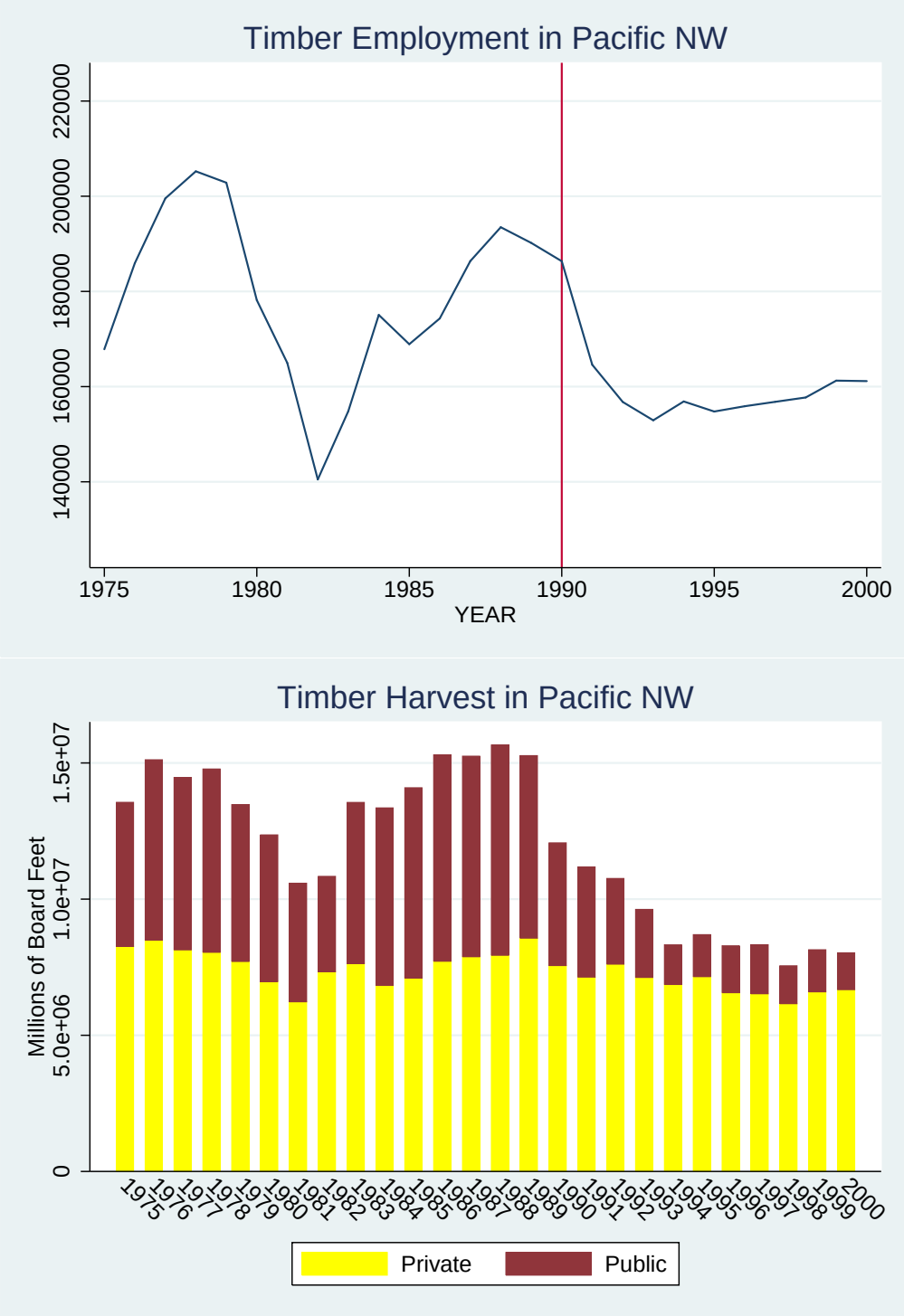


Figure 2: **Timber Harvests and Employment in Pacific Northwest, 1975-2000.**

Sources: Timber harvest data is by county and source (public or private owner), for Oregon and Washington, aggregated to the region. Data from the Oregon Dept. of Forestry, and the Washington Dept. of Natural Resources. Timber employment data is also by county, for Oregon, Washington, and California, from the BLS Quarterly Census of Employment and Wages, SIC 24, annual averages.

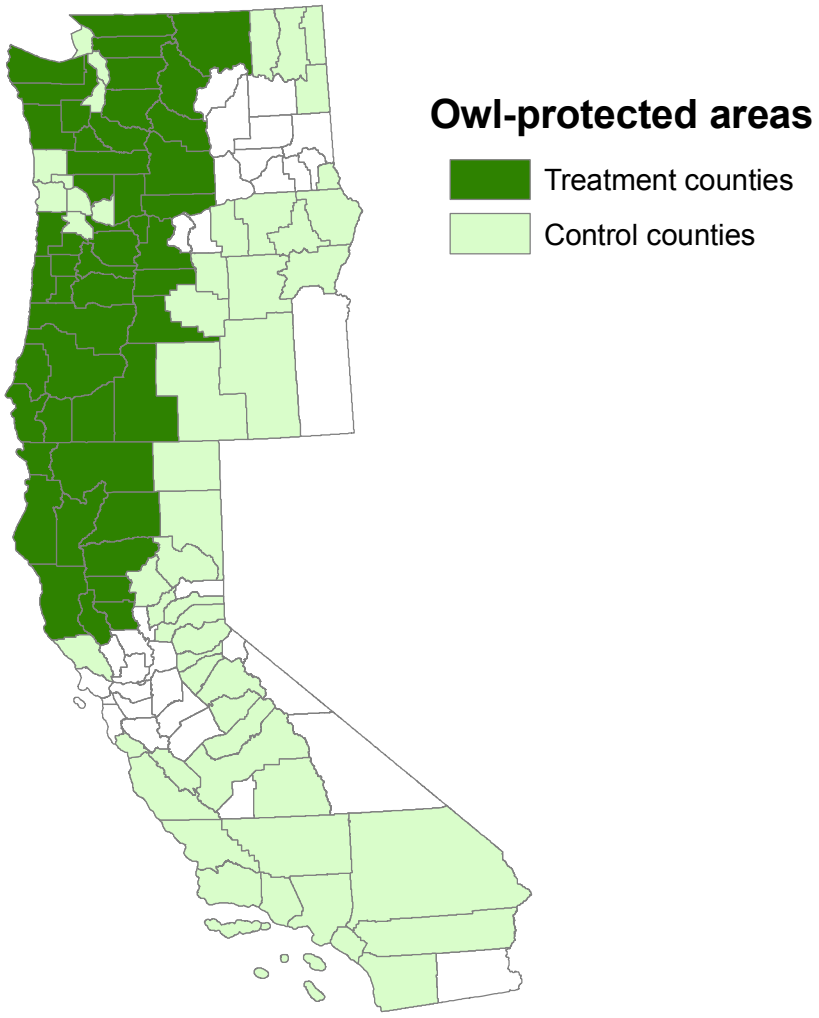
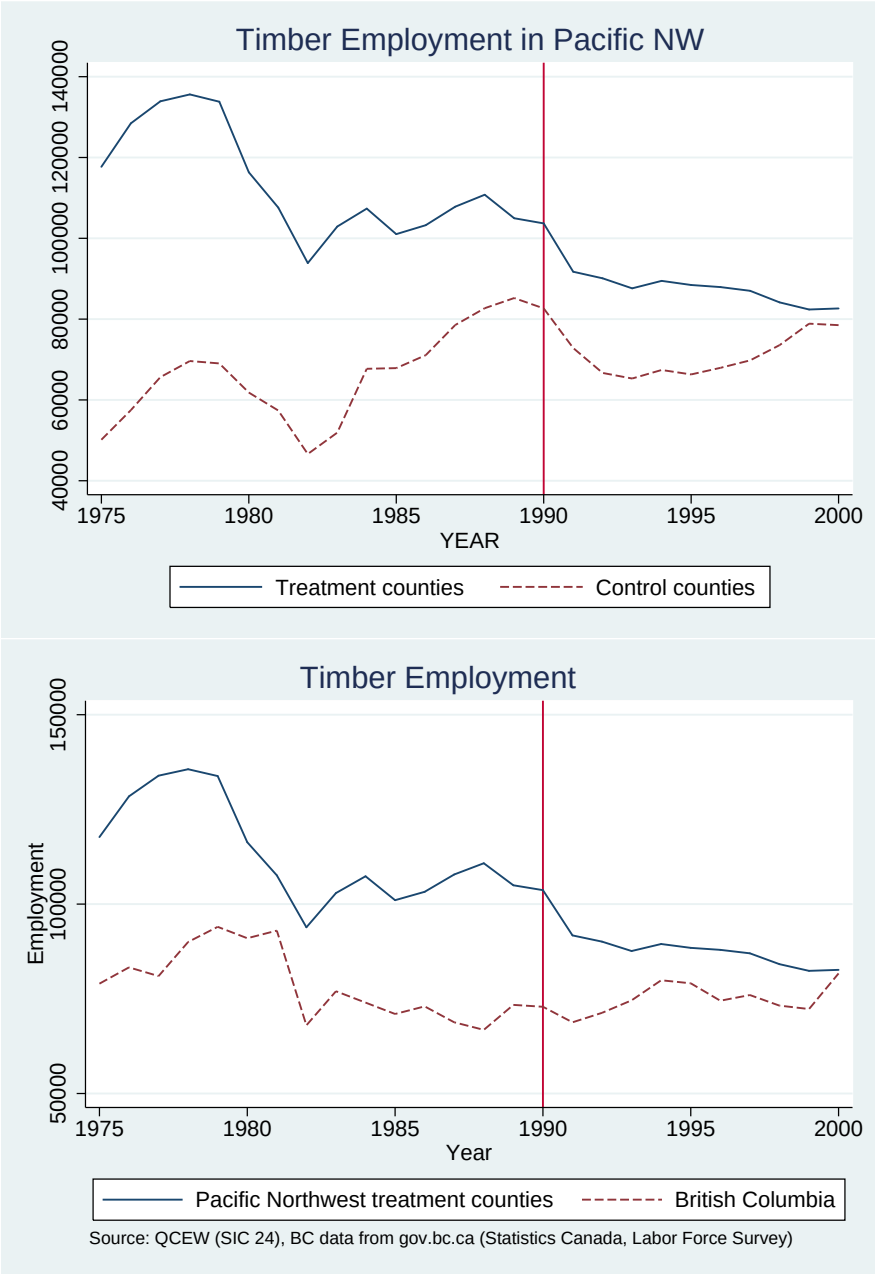


Figure 3: **Timber Employment in the Pacific Northwest, by Treatment and Comparison Counties.**

Source: REO GIS data for 1992 critical habitat areas for the northern spotted owl, and author's calculations. Darker green counties have some owl critical habitat areas. Lighter green counties do not have owl critical habitat, but do have some publicly owned timberland. County boundaries for Oregon, Washington and California.

Figure 4: **Timber Employment in Pacific Northwest and British Columbia, 1975-2000.**



Sources: Timber employment data is by county for Oregon, Washington, and California, from the BLS Quarterly Census of Employment and Wages, SIC 24, annual averages. British Columbia data from Statistics Canada, Labor Force Survey.

Table 2: **Change in Timber Employment, Growth in Earnings and Earnings per Worker — Treatment Counties (1975-2000)**

Average annual levels or growth:	**Treatment counties (with owl protected areas)**
Timber employment ($N = 1241$)	
pre-owl, 1975-1989	2,391.93
	(88.27)
post-owl, 1990-2000	1,846.95
	(78.87)
Growth in timber employment ($N = 1171$)	
pre-owl, 1975-1989	-0.01
	(0.01)
post-owl, 1990-2000	-0.03
	(0.00)
Growth in timber earnings ($N = 1171$)	
pre-owl, 1975-1989	0.04
	(0.01)
post-owl, 1990-2000	-0.00
	(0.01)
Growth in timber earnings per worker ($N = 1171$)	
pre-owl, 1975-1989	0.05
	(0.00)
post-owl, 1990-2000	0.03
	(0.00)

Source: Author's calculations, BLS Quarterly Census of Employment and Wages data, OR, WA, and CA: 1975-2000. *Note:* Table reports average change in levels of timber employment over the two time periods, within the treatment counties. Table also reports growth in employment or earnings, measured as annual differences in the logarithm of timber employment, earnings, or earnings per worker. Huber-White standard errors in parentheses. **Treatment counties** identifies 48 counties, which had some owl protected areas in 1992.

Table 3: **Timber Employment: After - Before Owl Regulation**

Treatment counties only:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
post-1990	-0.319	-0.276***	-0.276***	-0.276***	-0.320***	-0.291***	-0.302***	-0.293***
	(0.000)	(0.062)	(0.087)	(0.062)	(0.040)	(0.048)	(0.060)	(0.061)
ln(private timberland)				0.971***		1.980**	0.872***	1.130***
				(0.140)		(0.948)	(0.165)	(0.004)
ln(public timberland)				-0.058		-3.869**	-0.040	-0.007***
				(0.157)		(1.495)	(0.148)	(0.001)
County dummies:			X					X
Number of time periods:	2	2	2	2	26	26	26	26
Number of county-groups:	1	48	48	48	1	1	48	48
Adj. R^2	1.000	0.010	0.977	0.548	0.673	0.690	0.401	0.941
N	2	96	96	96	26	26	1221	1221
Comparison counties only:								
post-1990	-0.011	-0.116	-0.045	-0.135	-0.009	-0.031	-0.040	-0.032
	(0.000)	(0.103)	(0.107)	(0.114)	(0.053)	(0.054)	(0.076)	(0.069)
ln(private timberland)				-0.043		-0.146	-0.132	-0.450***
				(0.197)		(0.392)	(0.165)	(0.000)
ln(public timberland)				0.201		0.688***	0.192	0.005***
				(0.130)		(0.225)	(0.121)	(0.001)
County dummies:			X					X
Number of time periods:	2	2	2	2	26	26	26	26
Number of county-groups:	1	57	57	52	1	1	57	57
Adj. R^2	1.000	0.001	0.966	0.045	0.001	0.189	0.054	0.926
N	2	113	113	103	26	26	1233	1233

Source: BLS 1975-2000 annual averages by county for 3 states: OR, WA, CA. Employment in Lumber and Wood Products sector. *Note:* Dependent variable is ln(Timber Employment). Treatment counties have some owl-protected habitat. Comparison counties have non-zero amounts of timber employment and some timberland area. Robust standard errors in parentheses. Pooled OLS results are clustered at the county level, when applicable.

Table 4: **Timber Employment: Difference-in-Differences**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
post-1990*owl	-0.308	-0.160	-0.231*	-0.227	-0.311***	-0.311***	-0.289***	-0.278***	-0.261***
	—	(0.120)	(0.138)	(0.141)	(0.052)	(0.073)	(0.084)	(0.091)	(0.092)
owl=1	1.151	1.177***	—	—	1.151***	1.151***	0.444	—	—
	—	(0.279)	—	—	(0.043)	(0.061)	(0.967)	—	—
post-1990=1	-0.011	-0.116	-0.045	-0.049	-0.009	—	—	—	—
	—	(0.103)	(0.107)	(0.111)	(0.053)	—	—	—	—
ln(private				-0.289***			-0.090		-0.286***
timberland)				(0.003)			(0.700)		(0.002)
ln(public				0.906***			0.661		0.896***
timberland)				(0.016)			(0.412)		(0.009)
County dummies:			X	X				X	X
Year dummies:						X	X	X	X
Number of									
time periods:	2	2	2	2	26	26	26	26	26
Number of									
county groups:	2	105	105	100	2	2	2	105	100
Adj. R^2	1.000	0.129	0.974	0.974	0.947	0.984	0.987	0.944	0.946
N	4	209	209	199	52	52	52	2563	2454

Source: BLS 1975-2000 annual averages by county for 3 states: OR, WA, CA. Employment for Lumber and Wood Products only (SIC 24).
Note: Dependent variable is ln(timber employment). Pooled OLS results are clustered at the county level, when applicable. Treatment counties, *owl = 1*, had some owl-protected habitat (N=48), while comparison counties had none, but did have non-zero timber employment. Robust standard errors in parentheses, clustered at the county level where applicable.

Table 5: **Timber Employment: Size of Owl-Protected Areas in Treatment Counties**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
post-1990*ln(owl acres)	-0.114**	-0.114	-0.114	-0.060**	-0.059*	-0.085***	-0.093*	-0.093*
	(0.053)	(0.075)	(0.075)	(0.029)	(0.029)	(0.013)	(0.051)	(0.051)
(post-1990*ln(owl acres))^2	-0.011	-0.011	-0.011	-0.054**	-0.054**	-0.033***	-0.025	-0.025
	(0.037)	(0.052)	(0.052)	(0.020)	(0.020)	(0.006)	(0.032)	(0.032)
post-1990 = 1	-0.269***	-0.269**	-0.269**	-0.267***	—	—	—	—
	(0.077)	(0.109)	(0.109)	(0.044)	—	—	—	—
ln(owl acres)	0.554**	0.700***	0.231***	0.404***	0.404***	0.137***	0.514***	0.402***
	(0.215)	(0.037)	(0.037)	(0.013)	(0.013)	(0.008)	(0.022)	(0.020)
ln(owl acres)^2	0.036	0.255***	0.106***	0.162***	0.162***	0.065***	-0.014	0.167***
	(0.162)	(0.026)	(0.026)	(0.011)	(0.011)	(0.005)	(0.013)	(0.013)
ln(private timberland)			1.165***			0.850***		0.917***
			(0.000)			(0.017)		(0.009)
ln(public timberland)			-0.207***			-0.106***		0.156***
			(0.000)			(0.007)		(0.003)
County dummies:		X	X					X
Year dummies:					X	X	X	X
Number of time periods:	2	2	2	26	26	26	26	26
Adj. R^2	0.143	0.979	0.979	0.118	0.126	0.415	0.951	0.951
N	96	96	96	1221	1221	1221	1221	1221

Source: BLS 1975-2000 annual averages by county for 3 states: OR, WA, CA. Employment for Lumber and Wood Products only (SIC 24).
Note: Dependent variable is ln(timber employment). Pooled OLS results are clustered at the county level, when applicable. *Owl acres* is amount of spotted owl critical habitat in the county; private and public timberland are also at the county-level. Robust standard errors in parentheses, clustered at the county level where applicable.

Table 6: **Timber Earnings per Worker: Difference-in-Differences**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
post-1990*owl	-0.023	-0.013	-0.031	-0.037	-0.022**	-0.022	-0.014	-0.023	-0.019
	—	(0.036)	(0.045)	(0.044)	(0.010)	(0.014)	(0.011)	(0.026)	(0.027)
owl=1	0.103	0.107***	—	—	0.102***	0.102***	-0.282**	—	—
	—	(0.028)	—	—	(0.008)	(0.011)	(0.124)	—	—
post-1990=1	0.404	0.386***	0.404***	0.410***	0.405***	—	—	—	—
	—	(0.029)	(0.034)	(0.032)	(0.062)	—	—	—	—
ln(private				0.047***			0.167*		0.047***
timberland)				(0.001)			(0.087)		(0.001)
ln(public				-0.041***			0.155**		-0.042***
timberland)				(0.005)			(0.071)		(0.003)
County dummies:			X	X				X	X
Year dummies:						X	X	X	X
Number of									
time periods:	2	2	2	2	26	26	26	26	26
Number of									
county groups:	2	105	105	100	2	2	2	105	100
Adj. R^2	1.000	0.505	0.915	0.924	0.593	0.998	0.999	0.901	0.902
N	4	209	209	199	52	52	52	2563	2454

Source: BLS 1975-2000 annual averages by county for 3 states: OR, WA, CA. Employment for Lumber and Wood Products only (SIC 24).
Note: Dependent variable is ln(timber earnings per worker). Treatment counties, *owl = 1*, had some owl-protected habitat (N=48), while comparison counties had none, but did have non-zero timber employment. Robust standard errors in parentheses. Pooled OLS results are clustered at the county level, when applicable.

Table 7: **Non-Timber Employment: Difference-in-Differences**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
post-1990*owl	0.002	0.018	-0.005	0.015	-0.001	-0.001	-0.004	-0.002	0.005
	—	(0.049)	(0.064)	(0.064)	(0.041)	(0.058)	(0.065)	(0.040)	(0.042)
owl=1	0.073	0.233	—	—	0.071***	0.071*	0.369	—	—
	—	(0.333)	—	—	(0.024)	(0.034)	(0.530)	—	—
post-1990=1	0.538	0.512***	0.535***	0.514***	0.542***	—	—	—	—
	—	(0.041)	(0.052)	(0.052)	(0.098)	—	—	—	—
ln(private				-0.809***			-0.361		-0.812***
timberland)				(0.001)			(0.461)		(0.001)
ln(public				1.001***			0.098		1.013***
timberland)				(0.007)			(0.267)		(0.004)
County dummies:			X	X				X	X
Year dummies:						X	X	X	X
Number of									
time periods:	2	2	2	2	26	26	26	26	26
Number of									
county groups:	2	105	105	100	2	2	2	105	100
Adj. R^2	1.000	0.025	0.996	0.996	0.583	0.981	0.983	0.994	0.993
N	4	209	209	199	52	52	52	2563	2454

Source: BLS 1975-2000 annual averages by county for 3 states: OR, WA, CA.
Note: Dependent variable is ln(non-timber employment), where *non-timber*, by county, is all employment less timber employment. Pooled OLS results are clustered at the county level, when applicable. Treatment counties, *owl = 1*, had some owl-protected habitat (N=48), while comparison counties had none, but did have non-zero timber employment. Robust standard errors in parentheses.

Table 8: **Non-Timber Earnings per Worker: Difference-in-Differences**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
post-1990*owl	-0.062	-0.058***	-0.063**	-0.061**	-0.061***	-0.061***	-0.058***	-0.058***	-0.053***
	(0.000)	(0.020)	(0.028)	(0.029)	(0.009)	(0.012)	(0.015)	(0.017)	(0.017)
owl=1	0.017	0.027	—	—	0.016*	0.016	-0.086	—	—
	—	(0.024)	—	—	(0.008)	(0.012)	(0.162)	—	—
post-1990=1	0.509	0.499***	0.504***	0.502***	0.511***	—	—	—	—
	—	(0.015)	(0.021)	(0.021)	(0.068)	—	—	—	—
ln(private timberland)				-0.039***			-0.025		-0.037***
				(0.001)			(0.092)		(0.000)
ln(public timberland)				0.035***			0.106		0.033***
				(0.003)			(0.075)		(0.002)
County dummies:			X	X				X	X
Year dummies:						X	X	X	X
Number of time periods:	2	2	2	2	26	26	26	26	26
Number of county groups:	2	105	105	100	2	2	2	105	100
Adj. R^2	1.000	0.743	0.966	0.966	0.657	0.998	0.999	0.964	0.965
N	4	209	209	199	52	52	52	2563	2454

Source: BLS 1975-2000 annual averages by county for 3 states: OR, WA, CA.
Note: Dependent variable is ln(timber earnings per worker), where *non-timber*, by county, is earnings per worker for all sectors less earnings per worker for timber. Robust standard errors in parentheses. Pooled OLS results are clustered at the county level, when applicable. Treatment counties, *owl = 1*, had some owl-protected habitat (N=48), while comparison counties had none, but did have non-zero timber employment.

Table 9: **Employment: DDD**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
post-1990*timber*owl	-0.310	-0.310***	-0.295***	-0.310***	-0.295***	-0.310***	-0.295***
	—	(0.084)	(0.085)	(0.083)	(0.084)	(0.084)	(0.085)
owl=1	0.073	—	—	0.071	0.394	—	—
	—	—	—	(0.329)	(0.323)	—	—
post-1990=1	0.538	0.538***	0.533***	—	—	—	—
	—	(0.035)	(0.038)	—	—	—	—
timber=1	-5.031	-5.031***	-4.799***	-5.031***	-4.799***	-5.031***	-4.799***
	—	(0.235)	(0.226)	(0.233)	(0.225)	(0.236)	(0.227)
post-1990*owl	0.002	0.014	0.019	0.001	0.012	0.015	0.019
	—	(0.045)	(0.047)	(0.064)	(0.066)	(0.045)	(0.047)
timber*owl	1.079	1.079***	0.847***	1.079***	0.847***	1.079***	0.847***
	—	(0.279)	(0.271)	(0.276)	(0.269)	(0.279)	(0.272)
post-1990*timber	-0.549	-0.549***	-0.563***	-0.549***	-0.563***	-0.549***	-0.563***
	—	(0.061)	(0.062)	(0.061)	(0.062)	(0.061)	(0.062)
Timberland dummies:			X		X		X
County dummies:		X	X			X	X
Year dummies:				X	X	X	X
Adj. R^2	1.000	0.932	0.936	0.716	0.718	0.933	0.937
N	8	5126	4908	5126	4908	5126	4908

Source: BLS 1975-2000 annual averages by county for 3 states: OR, WA, CA.
Note: Dependent variable is ln(employment). Robust standard errors in parentheses. Pooled OLS results are clustered at the county level, when applicable. Treatment counties, *owl = 1*, had some owl-protected habitat (N=48), while comparison counties had none, but did have non-zero timber employment.

Table 10: **Earnings per Worker: DDD**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
post-1990*timber*owl	0.039	0.039	0.038	0.039	0.038	0.039	0.038
	—	(0.025)	(0.026)	(0.024)	(0.025)	(0.025)	(0.026)
owl=1	0.017	—	—	0.016	-0.008	—	—
	—	—	—	(0.023)	(0.025)	—	—
post-1990=1	0.509	0.510***	0.504***	—	—	—	—
	—	(0.012)	(0.013)	—	—	—	—
timber=1	0.241	0.241***	0.264***	0.241***	0.264***	0.241***	0.264***
	—	(0.026)	(0.025)	(0.026)	(0.025)	(0.026)	(0.025)
post-1990*owl	-0.062	-0.061***	-0.055***	-0.061***	-0.055***	-0.060***	-0.055***
	—	(0.017)	(0.017)	(0.016)	(0.017)	(0.017)	(0.017)
timber*owl	0.087	0.087***	0.064**	0.087***	0.064**	0.087***	0.064**
	—	(0.030)	(0.029)	(0.030)	(0.029)	(0.030)	(0.029)
post-1990*timber	-0.105	-0.105***	-0.104***	-0.105***	-0.104***	-0.105***	-0.104***
	(0.000)	(0.018)	(0.020)	(0.018)	(0.019)	(0.018)	(0.020)
Timberland dummies:			X		X		X
County dummies:		X	X			X	X
Year dummies:				X	X	X	X
Adj. R^2	1.000	0.639	0.648	0.775	0.789	0.880	0.886
N	8	5126	4908	5126	4908	5126	4908

Source: BLS 1975-2000 annual averages by county for 3 states: OR, WA, CA.
Note: Dependent variable is ln(earnings per worker). Robust standard errors in parentheses. Pooled OLS results are clustered at the county level, when applicable. Treatment counties, *owl = 1*, had some owl-protected habitat (N=48), while comparison counties had none, but did have non-zero timber employment.

Table 11: **Timber Harvests, by Treatment and Comparison Counties, and by Public and Private Ownership**

	Treatment Counties			**Comparison Counties**		
	(1) total harvest	(2) private harvest	(3) public harvest	(4) total harvest	(5) private harvest	(6) public harvest
post 1990 = 1	-0.63***	-0.17	-1.15***	0.14	0.23	-0.97**
	(0.09)	(0.12)	(0.15)	(0.12)	(0.20)	(0.36)
ln(private timberland)	0.96***	1.42***	0.44***	0.71***	1. 08***	0.16*
	(0.10)	(0.09)	(0.11)	(0.19)	(0.14)	(0.09)
ln(public timberland)	0.15*	-0.10	0.64***	0.27*	-0.07	0.80***
	(0.08)	(0.10)	(0.11)	(0.14)	(0.11)	(0.11)
Adj. R^2	0.751	0.679	0.653	0.669	0.702	0.629
N	970	988	968	686	695	634

Source: Timber harvest data, by county and owner (public or private), annual, for Oregon and Washington only. Timber harvest in million board feet; timberland in acres. Pooled OLS, 1975-2000; includes year & state effects.

Table 12: **Timber Employment: Difference-in-Differences Before Owl Regulation: 1980-82 Recession**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
owl*1980-82	0.116	0.119	0.065	0.109*	0.116**	0.116	-0.038	0.064	0.095**
	—	(0.140)	(0.068)	(0.063)	(0.054)	(0.076)	(0.140)	(0.043)	(0.042)
1980-82=1	-0.219	-0.106	-0.171***	-0.214***	-0.220**	—	—	—	—
	—	(0.069)	(0.057)	(0.050)	(0.082)	—	—	—	—
owl=1	1.128	1.169***	—	—	1.128***	1.128***	0.376	—	—
	—	(0.280)	—	—	(0.053)	(0.075)	(1.616)	—	—
ln(private timberland)				-0.286***			-0.431		-0.279***
				(0.001)			(0.792)		(0.000)
ln(public timberland)				0.830***			1.045		0.837***
				(0.007)			(0.699)		(0.002)
County dummies:			X	X				X	X
Year dummies:						X	X	X	X
Number of time periods:	2	2	2	2	15	15	15	15	15
Number of county groups:	2	105	105	100	2	2	2	105	100
Adj. R^2	1.000	0.170	0.993	0.995	0.953	0.984	0.989	0.964	0.968
N	4	205	205	195	30	30	30	1480	1416

Source: BLS 1975-1989 annual averages by county for 3 states: OR, WA, CA.
Note: Dependent variable is ln(timber earnings per worker), where *non-timber*, by county, is earnings per worker for all sectors less earnings per worker for timber. Robust standard errors in parentheses. Pooled OLS results are clustered at the county level, when applicable. Treatment counties, *owl = 1*, had some owl-protected habitat (N=48), while comparison counties had none, but did have non-zero timber employment. Policy indicator is for recession years: 1980, 1981, and 1982.