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The Effects of Critical Habitat Designation on Housing Supply: An Analysis of California Housing Construction Activity*

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Abstract

Under the Endangered Species Act, the U.S. Fish and Wildlife Service is required to designate critical habitat for listed species. Designation could result in modification to or delay of residential development projects within habitat boundaries, generating concern over potential housing market impacts. This paper draws upon a large dataset of municipal-level (FIPS) building permit issuances and critical habitat designations in California over a 13-year period to identify changes in the spatial and temporal pattern of development activity associated with critical habitat designation. We find that the proposal of critical habitat results in a 20.5% decrease in the annual supply of housing permits in the short-run and a 32.6% decrease in the long-run. Further, the percent of the FIPS area that is designated as critical habitat significantly affects the number of permits issued. We also find that the impact varies across the two periods in which critical habitat is designated and by the number of years relative to when critical habitat was first proposed.

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1. Introduction

Under Section 4(b)(2) of the Endangered Species Act, the U.S. Fish and Wildlife Service (the Service) is required to designate areas viewed as essential to listed species conservation and requiring special management protections as "critical habitat." Designation identifies geographic units of habitat with distinct boundaries, within which certain public and private activities or projects may require review and/or modification as recommended by the Service. As part of this process, the Service is required to conduct an economic analysis, and may exclude areas from designation if the costs of including the areas within critical habitat are believed to outweigh the benefits, provided the exclusion will not result in extinction of the species (16 U.S.C. §1533(b)(2)).

Critical habitat for nearly 500 species has been designated throughout the U.S. Many of these designations have received a high degree of scrutiny and opposition, especially where habitat overlaps with resource-based industry or incompatible recreational uses. Potential housing and development-related impacts have also received a great deal of attention in critical habitat economic analyses. Designation may cause developers to alter project plans within habitat boundaries and/or delay construction activities pending Service consultation. In some areas where population is growing rapidly, there is concern that designation may constrain housing supply and drive up prices, with corresponding negative impacts to local economies (e.g. Sunding et al., 2003). However, little corroborating empirical evidence of such an effect exists.

In this paper, we test the hypothesis that the designation of critical habitat has had a depressive effect on development activity. We carry out the test using a large panel dataset of counts of building permits issued in California municipalities (Federal Information Processing Standards or FIPS) for 1990-2002, which we adopt as a surrogate measure for the level of construction activity. By arraying these data spatially in a Geographic Information Systems (GIS) model and combining them with information on a number of designations over time, we test whether designation in a given municipality results in reduced permitting relative to a no-designation scenario.

In Section 2, we provide additional background information on critical habitat designation. In Section 3, we summarize the literature that is relevant to our analysis. In Section 4, we discuss our data sources. Section 5 describes our analytical framework. We develop two approaches to testing the hypothesis that critical habitat designation reduces development activity. First we employ a matched pair analysis by comparing FIPS in which critical analysis was designated with the closest FIPS where critical habitat was not proposed. Then we develop a model of building permit issuances based on the analysis in Mayer and Somerville (2000a, 2000b). In Section 6 we present the results of our empirical analysis. The model that best controls for the endogeneity of critical habitat designation is a partial adjustment model that includes FIPS-specific fixed effects and a lagged dependent variable. We find that the proposal of critical habitat results in a 20.5% decrease in the annual supply of housing permits in the short-run and a 32.6% decrease in the long-run. Further, the percent of the FIPS area that is designated as critical habitat significantly affects the number of permits issued. We also find that the impact varies across the two periods in which critical habitat is designated (1994-1995 versus 2000-2001) and by the number of years relative to when critical habitat was first proposed. Finally, we present concluding remarks in Section 7.

2. Critical Habitat Designation

The Endangered Species Act (the Act), enacted by Congress in 1973, is administered by the U.S. Fish and Wildlife Service (the Service) in conjunction with the National Marine Fisheries Service. The Service's role is to identify species in danger of extinction and to advance methods for their conservation and protection, in the hopes of eventually removing endangered and threatened species from the Federal endangered species list.

Listing species is the primary method by which the Act affords protection. Section 9 of the Act, and the Service's regulations, prohibit any action that results in the "take" of a listed animal species; that is, actions involving harassing, killing, capturing or otherwise harming endangered and threatened species. Furthermore, section 7 of the Act stipulates that Federal agencies must consult with the Service regarding any actions they fund, authorize, or carry out that may affect a listed species or designated critical habitat.

Critical habitat is defined in section 3 of the Act as: (i) the specific areas within the geographic area occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) that may require special management considerations or protection and; (ii) specific areas outside the geographic area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. (16 U.S.C. § 1532(5)(A)).

Under the Act, the purpose of critical habitat is to help protect those areas that are identified as being essential for the conservation of the species. Critical habitat provides benefits to the species by informing the public and private sectors of areas that are important for species recovery and where conservation actions would be most effective (in addition to regulatory protection under section 7, as mentioned above).

The Act contains specific provisions that preclude economic and other non-biological criteria from being a factor in listing decisions. Section 4(b)(1)(A) of the Act stipulates that listing determinations must be made solely on the basis of biological evidence. Section 4(b)(2) of the Act, which calls for the establishment of critical habitat for all listed species if it is prudent and determinable, also requires critical habitat designations to be made on the basis of the best scientific data available (16 U.S.C. § 1531(b) 1994). This section adds, however, in contrast to listing provisions, that the economic impact of the designation and any other relevant impacts should be taken into consideration before specifying any particular area as critical habitat. As a consequence, areas where the costs of designation are believed to be greater than the benefits can be excluded from critical habitat designation.

Our analysis focuses on California since so many recent listings have occurred there. As of 2003 there were 82 listed species in California and 68 critical habitat designations (note that more than one species can be included in a single designation). Figure 1 displays the geographic extent of these combined designations. As shown, while a significant portion of critical habitat exists in less-populated areas in the southeast, there is a considerable amount of designated area in urban and suburban portions of the San Francisco Bay area, Los Angeles, and San Diego. Note that we use the terms “critical habitat proposal” and “critical habitat designation” interchangeably in this paper. Technically, critical habitat is first proposed (at which point species information and maps get released to the public), and then following the economic analysis, public hearings and solicitation of comments, etc., is (possibly amended in some fashion and then) finalized. So the proposal details where the critical habitat will be, but the actual "designation" corresponds to the final unit boundaries. From a practical standpoint, though, there is little difference between the concept of first proposal and final designation. Further, final designation usually occurs soon after proposal of critical habitat; in our data almost two-thirds of critical habitat actions were finalized in the same calendar year of critical habitat proposal.

3. Literature Review

Two literatures that are relevant to this analysis are the one on housing supply and the one on the impact of regulation on housing. As noted by DiPasquale (1999), there has been relatively little analysis of the supply of housing relative to the demand for housing. For our purposes, the key paper in this literature is Mayer and Somerville (2000a). The authors develop a model of housing supply that is based on the Capozza-Helsley urban growth model. While housing price is determined in the market so as to equilibrate supply and demand, it is the change in price that will affect the change in supply or housing starts. Thus, Mayer and Somerville model housing starts as a function of the change in house price and housing construction costs. Since new housing development will not occur immediately, they include lags of house price and construction cost changes in their model.

Mayer and Somerville compare their model to another important model in the literature; DiPasquale and Wheaton's (1994) stock adjustment model. In this model, housing starts are proportional to this period's desired stock and last period's existing stock (net of depreciation). The current house price is used as a proxy for desired stock and lagged stock is included as a regressor. Mayer and Somerville note that the DiPasquale-Wheaton approach recognizes the difference between housing supply as a stock and starts as a flow but the stock of housing is difficult to measure in non-census years since depreciation and removal are not observed.

Mayer and Somerville use quarterly national data from 1975-1994 to estimate their model. As they note, this requires two strong assumptions: 1) the model is applicable to national data, and 2) a single national housing market exists. The resulting model includes three lags of the price change variable though only the first two are significant. They estimate that the contemporaneous, one quarter, price elasticity of housing starts is 6.3% while the annual elasticity is 3.7%. Finally, the coefficient on the change in construction costs is not significant.

In Mayer and Somerville (2000b), the authors use quarterly data for 44 MSAs between 1985 and 1996 to estimate the model they developed in the previous paper. The focus of this paper is on the impact of land use regulation on residential construction. The main model is a regression of the natural log of permits on the growth rate of house prices and 5 lags of this growth rate, variables capturing land use regulation (months to receive subdivision approval, number of growth management techniques, and a dummy for the presence of development fees), the change in the real prime rate, and the log of MSA population in 1980. First, Mayer and Somerville estimate a version of the model that corrects for first-order serial correlation and an MSA-specific error term. The evidence indicates that regulation reduces housing permits. Increasing the number of months to receive subdivision approval by one standard deviation reduces the number of permits by 20-25% while adding a growth management technique reduces the number of permits by 7%. The coefficient for the variable indicating development fees is not significant.

Mayer and Somerville then correct for the endogeneity of regulation using as instruments the number of jurisdictions with land use control, Reagan's share of the MSAs 1984

U.S. presidential vote, an index of traffic congestion, MSA 1975 per capita income, the percentage of adult population with high school degrees, the 1980 population, and whether the state has citizen referendums. The result is the expected increase in standard errors and a large increase in the estimated coefficient for one of the regulation variables. They state that "We believe this effect to be too strong and suspect it is a result of our choice of instruments." Nonetheless, these results indicate quite clearly that the negative effect of regulation on housing starts is not an artifact of endogeneity but a real impact on builder behavior." Page 654. It should be noted that Mayer and Somerville do not use a fixed effects estimator. This is because the regulation variables do not change over time and hence would be excluded from the model if the fixed effects estimator was used.

Malpezzi (1996) analyzes the effects of regulation on housing prices. Both supply and demand-side factors are considered. The unit of analysis in this paper is the MSA. Prices are taken from three sources: 1) the decennial censuses, 2) the National Association of Realtors, and 3) hedonic house price indices (Thibodeau 1992). Malpezzi includes as regulations information on rent control, land-use and zoning, and infrastructure regulations and building codes. Results indicate that regulation raises housing rents and lowers homeownership rates. On the supply side, the log of housing permits per capita was regressed on the regulatory variables (among others). The results show that an increase in regulation reduced permits by 42%.

Quigley and Raphael (2004) note the high house prices in California and particularly the large increases in house prices between July 2000 and July 2003. They also note that California has a high level of regulation that affects land use and residential construction because cities have relative autonomy in setting these regulations. Quigley and Raphael consider three hypotheses that are consistent with the fact that this high level of regulation is causing the high house prices in California: 1) housing is more expensive in more regulated cities, 2) growth in the city-level housing stock depends on the degree of regulation and, 3) the price elasticity of housing supply is lower in more regulated cities.

To test these hypotheses, Quigley and Raphael use data from the 1990 and 2000 Public Use Microdata Samples (PUMS) to generate house price indices for 407 cities in California for both owner-occupied and rental housing units. Data on land use and residential construction regulations come from a study by Glickfeld and Levine (1992). Quigley and Raphael generate a variable that is the number of 15 possible regulations that are in place in each city. Annual building permits for each city are obtained from the California Industry Research Board (CIRB).

To test the first hypothesis that housing is more expensive in more regulated cities, Quigley and Raphael regress housing prices (1990, 2000, and change) on the growth control index (the number of controls) with and without county fixed effects. The results with fixed effects show that an additional regulation results in a 1% increase in prices in 1990 and 2000 but has no effect on the change in prices between these years. To test the second hypothesis that the growth in the city-level housing stock depends on the degree of regulation, Quigley and Raphael regress the growth rate in housing supply on the growth control index and the growth in house prices. They instrument for the growth in house prices using estimated employment changes. The coefficient on the growth control index is negative and significant for single-family houses but not significant for multi-family houses.

To test the third hypothesis that the price elasticity of housing supply is lower in more regulated cities, Quigley and Raphael regress the growth rate in housing supply on the growth rate in prices. They run separate regressions for less and more regulated cities where less is defined as zero or one regulation in place and more as 2 or more regulations. Results show weak evidence of a positive supply elasticity in unregulated cities and a negative supply elasticity in regulated cities.

Margolis, Osgood, and List (2005) look at whether critical habitat designation (CHD) leads to preemptive habitat destruction (PHD). PHD often takes the form of premature land development or timber harvesting. The authors point out that 90% of listed species are found on private land and most have more than 80% of their habitat on private land. PHD is measured as the difference in the timing of permit applications between critical habitat (CH) and non-critical habitat land. The species studied is the Pigmy-owl near Tuscon, Arizona. In the case of the Pigmy-owl, designation was based only on biological criteria (even though CHD is supposed to take economic costs into consideration). This means that the development potential of the land should be independent of CHD. The authors assume independence conditional on such factors as distances to amenities and disamenities, soil types, and local housing values. They use propensity score matching to pair CH land parcels with similar non-CH land parcels.

The data include approximately 25,000 land parcels from January 1997 through February 2001. The main estimation is a probit/logit model of pre-emption. The dependent variable is permit application. Dummy variables for CHD are broken down by time periods corresponding to events that affected PHD. Generally, the results show that CH parcels were more likely to be developed. Further, the results suggest that CH land parcels were developed roughly 300 days earlier than similar non-CH parcels

The authors also examine the impact of CHD on the sales price of undeveloped land. They collected sales prices for 7,000 transactions during the analysis period. They find that the proposal of critical habitat (the release of the property map) results in a 20% reduction in price per acre (though the p-value is only 0.091).

Quigley and Swoboda (2004) apply the standard general equilibrium urban housing model (Brueckner 1987) to analyze the general equilibrium implications of CHD. CHD is specified by designating land where housing production is not allowed. The interesting case is where CHD occurs within the urban boundary. They use simulation to solve their model and then compare the outcomes before and after CHD. Results show that, given large enough set-asides due to CHD (4% of land where development is prohibited), the most significant impact on the urban area is the rise in the price of non-CHD land. A key assumption of the analysis is that the urban area is closed. This means that the population is fixed and no one is allowed to move out of the area after CHD. As Quigley and Swoboda point out, if this assumption is relaxed, then the cost of CHD is only the change in market value of the CHD land.

4. Data Description

The observation unit used in this study is a FIPS place.[1] FIPS boundaries follow either (1) the legal boundaries of incorporated areas (e.g., San Diego, Los Angeles, etc), or (2) Census Designated Place (CDP) boundaries established by the US Census (CDP boundaries are for unincorporated areas that support a sizable population). There is a fair amount of variation in the size of FIPS. The largest FIPS in this analysis is Los Angeles which is 303,000 acres with a population in 1990 of 3.5 million. The smallest FIPS is Amador City (approximately 30 miles south-east of Sacramento) which is 209 acres with a population in 1990 of 196.

The dataset includes the total number of permits granted each year for single-family detached and multi-family units (e.g., duplex, three/four, and five or more units) for

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[1] FIPS Codes are promulgated by the Federal government to facilitate data collection and processing and are established at a variety of geographic levels including, American Indian area, state, county, subcounty, metropolitan area, and place. For further information see the FIPS homepage http://www.itl.nist.gov/fipspubs/index.htm

approximately 400 FIPS places over the period 1990-2002, as recorded by the CIRB.[2] This represents the incorporated subset (with minor exceptions) of all California FIPS places and encompasses the majority of all land within FIPS boundaries. In this study, we focus on the number of single-family permits since they constitute the bulk of the permitting activity.

A GIS model was developed to geocode permit data, compile critical habitat designations and other information and construct variables to support the analysis. GIS data on FIPS places were obtained through the Census Bureau.[3] Figure 2 depicts the boundaries of FIPS included in this analysis.

GIS data were compiled from U.S. Fish and Wildlife Service offices for 39 critical habitat designations finalized in California between 1979 and 2003. Habitat has been designated for only a subset of the total number of federally listed species found in California and GIS spatial data are only available for a subset of these species. Table 1 provides an overview of the species-specific data relied upon in this analysis. In some cases, the originally designated habitat has since been vacated by court order, but remains in effect until a new designation is proposed and finalized by the Service. In these cases, we include the original designation in our analysis. In other cases, the vacated critical habitat is no longer valid and the revised GIS data are not available.

Three additional sources of data are utilized in our analysis. Housing price data were acquired from DataQuick Information Systems. These data provide information on the annual median selling price of single-family homes by city for the time period of our analysis. We also incorporate information on annual precipitation patterns. Data on total annual precipitation for over 200 monitoring stations throughout California were acquired from the Western Regional

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[2] We thank John Quigley for providing us with this data.
[3] http://www.census.gov/geo/www/cob/pl1990.html.

Climate Center. Using GIS, these stations were mapped to the nearest FIPS place. In many cases, a monitoring station existed within the boundaries of a given FIPS. Data on acres of forest, shrubland, water, and wetlands were constructed from United States Geological Service National Land Cover Data (NLCD), which in turn are derived from 1992 Landsat Thematic Mapper satellite data. The NLCD is a land cover classification scheme applied consistently across the United States. Twenty-one classes are grouped into nine categories, of which we examine four: Water, representing all areas of open water or permanent ice/snow cover (the latter being irrelevant to our analysis); Forested Upland, representing areas characterized by tree cover generally greater than six meters in height and where tree canopy accounts for 25-100 percent of the cover; Shrubland, representing areas characterized by woody vegetation less than six meters tall as individuals or clumps; and Wetlands, representing areas where soil or substrate is periodically saturated with or covered with water.

5. Analytical Approach

We employ two types of analyses to compare FIPS with and without critical habitat. The first compares acre-standardized permit frequencies between FIPS where critical habitat was proposed (CHP FIPS) and the nearest FIPS without critical habitat (non-CHP FIPS). The second is a series of regression models that draw upon the full panel dataset. These analyses are described further in the sub-sections below.

5.1 Neighbor Comparisons

Initially, we make simple comparisons of the mean number of single family permits per acre issued annually for CHP FIPS and non-CHP FIPS. Given that these two groups of cities might differ in ways that influence the number of permits issued, for each CHP FIPS, we generate a matched pair to try to minimize these potential differences. We choose the nearest non-CHP FIPS with the belief that the close proximity of the two FIPS will mean that they will be relatively similar in their development potential so that any difference in the number of permits issued (standardized by size of the FIPS) can be attributed to the designation of critical habitat.

To further isolate the impact of the proposed critical habitat designation, we consider two difference-in-difference estimators. First, we look at the mean change in permits per acre issued between the year that critical habitat is first proposed and the year prior to this event. That is, we compare the mean of $s_t - s_{t-1}$ for the CHP FIPS and the non-CHP FIPS (where s_t is the mean number of single family permits per acre in the year of critical habitat proposal (t)). Second, we compare the mean change in permits per acre issued between the year after critical habitat is first proposed and the year prior to this event. That is, we compare the mean of $s_{t+1} - s_{t-1}$ for the CHP FIPS and the non-CHP FIPS. This difference-in-difference comparison controls for other factors that caused the number of permits per acre to change between years.

For each year, we present two basic results. First we calculate the percent of times the number of permits per acre in the non-CHP FIPS exceeds that for the CHP FIPS. Second, we test whether the mean difference is statistically significant by performing paired t-tests. We then combine the years in a simple regression model to get an overall assessment of the difference in permits per acre across the two groups.

5.2 Regression Models

Housing starts occur for two reasons, 1) to replace existing stock that is demolished and 2) to meet increases in population growth (or, in general, increases in the demand for housing). Thus housing starts may occur to maintain an equilibrium stock of housing or they may arise in response to changing conditions that require an increase in the housing stock relative to last period. Mayer and Somerville (2000a) point out that it is the change in population, i.e. growth that pushes up housing prices and changes in other factors such as construction costs that will result in a change in the housing stock. Otherwise, the equilibrium housing stock will not change. Thus, they include changes in prices and costs of construction as regressors in their model of housing starts.

Our model is most similar to that in Mayer and Somerville (2000b) since they use MSA-level data and include measures of regulation in their model of housing starts. Our analysis differs from Mayer and Somerville (2000b) in at least three ways. First, we use a fixed effects estimator to control for unobserved factors that affect housing starts and are correlated with CHD. Second, we develop a partial adjustment model of housing starts. This results in the addition of a lagged dependent variable to the model. Third, we allow the impact of CHD to vary over time.

Initially, we specify a model of housing starts where the natural log of the number of permits or starts (*S*) issued in FIPS place *i* during year *t* is modeled as:

$$\begin{aligned} \ln S_{it} &= \beta_0 + \beta_1 \Delta \ln PRICE_{it} + \beta_2 CHP_{it} + \beta_3 CH\_AREA_{it} + \beta_4 CH\_EVER_i \\ &\quad + X_{it}\beta_5 + YEAR_t \beta_6 + u_i + \varepsilon_{it} \end{aligned} \qquad (1)$$

where $\Delta \ln PRICE_{it}$ is the percent change in the median house price[4], CHP_{it} is a binary variable that indicates whether or not critical habitat was proposed in FIPS place *i* in year *t* or in an earlier year, CH_AREA_{it} is the percent of the FIPS area that was finalized as critical habitat (this variable is zero when CHP_{it} is zero), and CH_EVER_i indicates if critical habitat was ever proposed in FIPS i. Further, X_{it} is a vector of other factors that affect the number of permits issued, $YEAR_t$ is a vector of year-specific dummy variables, u_i is a FIPS-specific effect, ε_{ij} is an unobserved error term, and $\beta_0,...,\beta_6$ are parameters to be estimated. We denote this equation as Model 1.

The year dummies will capture annual economic factors such as the interest rate. They will also pick up construction costs given that they are relatively constant across the FIPS in California that are included in this analysis. The FIPS-specific effect will capture unobserved time-invariant factors that make the FIPS more likely to be developed. These might include any time-invariant factors such as the distances to centers of economic activity and environmental amenities such as the Pacific Ocean or the existence of particular industries in the FIPS. X_{it} includes the natural logs of population and land area of the FIPS (we do not include the number of housing units since the correlation with population is 0.98). These two variables are based on the 1990 and 2000 censuses. We set each equal to the value from the 1990 Census for years 1990-1999 and we use the value from the 2000 census for years 2000-2002. The FIPS land area actually varies across censuses because in 2000 the Census Bureau modified the spatial boundary definitions of many of the FIPS in our sample. While, technically, the population in the FIPS is time varying, it only proxies for the true values in non-census years. Thus, we do not include population as a regressor in the fixed effects model. We do include the FIPS area variable since

[4] While there is some concern that the median house price index is not adjusted for quality, Meese and Wallace (1997) find little difference between this index and the constant quality house price index.

the areas only changed in 2000 so our variable accurately measures the actual FIPS area across all years of the sample. Plus, given that the number of building permits is clearly related to the size of the FIPS, we do not want any change in building permits due to the expansion or contraction of the FIPS in 2000 to be attributed to the proposal of critical habitat.

We also include two indices that measure the regulatory stringency of the FIPS; regulations that affect the ability to build new units in the FIPS. The first, *GROW*, is a pro-growth index while the second, *EXCLUDE*, is an index of existing growth-limiting regulations.[5] These variables are time-invariant since they are generated from data that was only collected for one year (1992). Interestingly, these two variables are positively correlated. Thus, it appears that FIPS are regulation "happy" or they are not.

Of primary interest are the three variables that indicate critical habitat designation. The binary variable CHP_{it} measures the impact on the number of permits issued once critical habitat has been proposed.[6] Note that this variable remains equal to 1 for all years after critical habitat has been proposed. Initially, we assume that the impact will be constant for all these years. Later on, we will allow the coefficient on CHP_{it} to vary over time to determine if the impact differs after the initial year in which critical habitat is proposed. Also, we allow for a non-zero impact prior to proposal to pick up possible preemptive activity (as discussed in Margolis et al 2005). Also, there are two distinct time periods when critical habitat was proposed: 1994-1995 and 2000-2001. We look at whether these were different in any way by comparing their observed characteristics and by allowing the impact of CHP_{it} to differ across the two groups in Model 1.

[5] These indices were originally developed by Glickfeld and Levine (1992) and were provided to us by John Quigley.
[6] We also look at the impact of final designation but generally final designation occurred at most two years after critical habitat was initially proposed and often occurred in the same year. In practice, a variable that accounted for final designation was never significant when included in the regression with CHP (the correlation between the two measures is approximately 0.7).

Note that the coefficient for CHP_{it} will measure the impact of the proposal of critical habitat regardless of the amount of land it covers. A significantly negative value of the coefficient for CHP_{it} will indicate that the proposal of critical habitat acts as a signal to developers of higher costs of development in general. This can occur if the proposal of critical habitat leads to greater regulatory stringency in CHP FIPS for all development.

To determine if the amount of critical habitat land affects the number of permits issued, we include the variable CH_AREA_{it} which measures the percent of the FIPS area that is proposed for critical habitat. We also include CH_EVER_i in Model 1 to measure any difference in the mean number of permits issued between CHP FIPS and non-CHP FIPS conditional on all the other regressors including the other two critical habitat variables. By including this variable, the coefficients on CHP_{it} and CH_AREA_{it} will more accurately measure the impact of proposing critical habitat and not any other underlying differences across the CHP FIPS and non-CHP FIPS.

An important concern with CHP_{it} and CH_AREA_{it} is that because economic costs can play a role in critical habitat designation, they are not likely to be exogenous. One might think that the critical habitat land will have less development potential, either because species tend to live in areas that are less likely to be developed or because there is a tendency not to designate areas that have high development potential as critical habitat. The former reason could occur because the most developable land, all things equal, does not provide good habitat for species. On the other hand, areas that exhibit the greatest development potential are the ones where species are most likely to be affected since their habitat is being destroyed. This is particularly true in California as new development is occurring in more remote areas with terrain more conducive to species habitat.

This discussion makes it clear that CHP_{it} and CH_AREA_{it} will likely be correlated with u_i in equation (1). One can view the addition of CH_EVER_i as one way of controlling for underlying differences in the CHP FIPS and non-CHP FIPS. This bias can also be removed by using an estimator that controls for u_i. One such estimator is the fixed effects estimator. The use of fixed effects will not completely correct the endogeneity bias if the change in permits as well as the level of permits affects CHP_{it} and CH_AREA_{it}. While this seems less likely, it is a source of bias that we must still address. One way of correcting the bias caused by the endogeneity of CHP_{it} and CH_AREA_{it} is to use instrumental variables. We use the annual rainfall and the number of acres of forest land, shrubland, water, and wetlands in each FIPS as an instrument. Thus we argue that rainfall and the number of acres of forest land, shrubland, water, and wetland are not correlated with building permits (conditional on the other regressors) but that these variables are correlated with the proposal of critical habitat. Since we have more than one potential instrument, we can test for the validity of all but two of them using the over-identification test (see Wooldridge 2003)

DiPasquale and Wheaton's (1994) stock-adjustment model for housing supply motivates a second model of permit issuance. Given the prevalence of land-use regulations, it is likely that there is a lag in obtaining new building permits. We use a partial adjustment approach to model permits in terms of the optimal level of permits, S_{it}^{*}, rather than the actual level, S_{it}

$$\begin{aligned} \ln S_{it}^{*} &= \beta_0 + \beta_2 \Delta \ln PRICE_{it} + \beta_3 CHP_{it} + \beta_4 CHF_{it} + \beta_5 CH\_EVER_i \\ &\quad + X_i \beta_6 + YEAR_t \beta_7 + u_i + \varepsilon_{it} \end{aligned} \qquad (2)$$

Given time lags in the permitting process, the market only partially adjusts to the desired level

$$\ln S_{it} - \ln S_{it-1} = \delta\left(\ln S_{it}^{*} - \ln S_{it-1}\right)$$

or

$$\ln S_{it} = \delta \ln S_{it}^{*} + (1-\delta)\ln S_{it-1} \qquad (3)$$

Substituting (2) into (3) gives

$$\begin{aligned}
\ln S_{it} &= \delta(\beta_0 + \beta_2 \Delta \ln PRICE_{it} + \beta_3 CHP_{it} + \beta_4 CH_AREA_{it} + \beta_5 CH_EVER_i \\
&\quad + X_{it}\beta_6 + YEAR_t \beta_7 + u_i + \varepsilon_{it}) + (1-\delta)\ln S_{it-1} \\
&= \alpha_0 + \alpha_1 \ln S_{it-1} + \alpha_2 \Delta \ln PRICE_{it} + \alpha_3 CHP_{it} + \alpha_4 CH_AREA_{it} + \alpha_5 CH_EVER_i \\
&\quad + X_{it}\alpha_6 + YEAR_t \alpha_7 + u_{1i} + \varepsilon_{1it}
\end{aligned} \qquad (4)$$

where

$$\alpha_1 = 1-\delta, u_{1it} = \delta u_{it}, \varepsilon_{1it} = \delta\varepsilon_{it}, \alpha_j = \delta\beta_j \quad j = 0,1,\ldots,7$$

The result is a model with a lagged dependent variable. Call this Model 2.

In both Mayer and Somerville papers (2000a, 2000b), the authors find evidence of first-order serial correlation in a model similar to Model 1 above. Their response is to correct for this using a Generalized Least Squares estimator. In the context of Model 2, one can also interpret the presence of first-order serial correlation in Model 1 as evidence of misspecified dynamics; the lagged dependent variable is excluded. Evidence in favor of Model 2 will be the presence of first order serial correlation in Model 1 and a significant estimate of α_1 and the absence of first-order serial correlation in Model 2.

6. Empirical Analysis

There are approximately 400 FIPS in the initial data set. Due to missing information, the final data set consists of a total of 385 FIPS. Definitions of the variables and their summary statistics are given in Table 2. Of the 385 FIPS in the data set, 121 had critical habitat proposed within their boundaries while the remaining 264 did not. Critical habitat was first proposed in two distinct time periods. In 1994 and 1995, critical habitat was proposed in 13 and 10 FIPS, respectively. In 2000 and 2001, critical habitat was proposed in 63 and 35 FIPS, respectively. Thus, most (81%) of the critical habitat proposals occurred at the end of our data period. One issue that we will investigate is whether there is any difference in these two groups of FIPS.

To get an idea if the FIPS where critical habitat was proposed (CHP FIPS) differ systematically from those where critical habitat was not proposed (non-CHP FIPS), we compare observable characteristics for these two groups. Further, we disaggregate the information for the CHP FIPS based on the two periods in which designation occurred. This information is given in Table 3. We see that the CHP FIPS are larger in population, the number of housing units, and area but are actually smaller in terms of population per acre and the number of housing units per acre than the non-CHP FIPS. The median price of single-family houses was higher in the CHP FIPS compared to the non-CHP FIPS during the 1990-1993 period. The means of both the pro-growth and growth-exclusion indices are higher in the CHP FIPS than in the non-CHP FIPS. Given the latter result, we don't necessarily expect the number of permits per acre issued to differ across the CHP FIPS and non-CHP FIPS because of existing land-use regulations. We see that, while the mean number of permits issued annually between 1990 and 1993 is higher in the CHP FIPS (because they are larger on average), the standardized (by acre) mean is actually higher in the non-CHP FIPS than in the CHP FIPS. Thus, without controlling for this difference, we might attribute the proposal of critical habitat to be the cause of this lower level of standardized permit issuance in the CHP FIPS.

When we compare the CHP FIPS where critical habitat was first proposed in 1994-1995 with those where critical habitat was first proposed in 2000-2001, the latter are smaller in population, number of housing units, and area. Yet the 2000-2001 CHP FIPS had a higher average number of single family permits issued during 1990-1993 and the average per acre was twice that of the 1994-1995 CHP FIPS. Thus there does seem to be a difference between the CHP FIPS based on when critical habitat was proposed.

6.1 Neighbor Comparisons

We conduct this analysis using all CHP FIPS and starting in 1994 when the first critical area was proposed. For the 120 CHP FIPS, the average distance to the nearest non-CHP FIPS neighbor is 1.3 miles.[7] The maximum distance is 11.5 miles. In order to make it more likely that the neighbor is similar to the FIPS with proposed critical habitat, we also restrict the maximum distance to be less than or equal to one and two miles. These restrictions reduced the number of FIPS with proposed critical habitat to 60 and 99, respectively. We present the mean values for the observable characteristics for the matched pairs under the column labelled "Neighbor" in Table 3. For the most part, these means are closer to the comparable values for the CHP FIPS than are the means for all non-CHP FIPS (column labelled "All"). The final column in Table 3 gives the p-values for the differences in the mean values for the CHP FIPS and their neighbors. While the standardized population and number of housing units and price are not significantly different at the 5% level, the mean standardized number of permits is significantly greater in the non-CHP FIPS. This appears to be driven, in part, by some large outliers. While the mean standardized number of permits in the non-CHP FIPS is 34% higher compared to the CHP FIPS, the median is on 16% higher. Further, when we look at CHP FIPS where the neighbor is at most one mile away, the mean and median values are only 17% and 10% higher in the non-CHP FIPS.

As discussed in Section 5.1, one comparison we make is the frequency with which permits per acre in CHP FIPS are less than in the neighboring non-CHP FIPS. Consistently

[7] One CHP FIPS was excluded from this analysis since its eight nearest neighbors were also CHP FIPS.

higher permits/acre in neighboring communities could suggest some effect associated with critical habitat. As Table 4 demonstrates, no consistent pattern emerges. The second comparison asks if the magnitude of differences in permits per acre is significant. Here, the mean number of permits is greater in the CHP FIPS relative to the non-CHP FIPS for all but the last two years. The p-values for the t-tests indicate that these differences are generally not significant though the p-values for the comparisons in 2001 and 2002 are 0.06 and 0.05, respectively.[8] When we restrict the maximum distance between FIPS to be two miles and one mile, the differences tend to increase. This is particularly true when we restrict the distance to one mile.

The difference in difference results are also given in Table 4. These comparisons are restricted to the years when the critical habitat was first proposed. Here we see that the change in permits in the CHP FIPS tended to be smaller than for the non-CHP FIPS. These differences are not significant but the results are influenced by the small number of FIPS in each comparison. These results do give some evidence that the proposal of critical habitat does adversely affect the issuance of building permits.

We then combine the annual comparisons in a simple regression model to get an overall assessment of the difference in permits across the two groups. We regress the number of permits per acre on year dummies and CHP_{it}. The results are presented in Table 5. When we use all observations, the estimated coefficient for CHP_{it} is negative but insignificant (p-value is 0.077). When we confine the observations to only those years in which the critical habitat was first proposed, the coefficient is still negative but much larger in magnitude and the p-value is 0.025.

[8] It is important to note that the number of FIPS places in California, as designated by the Census Bureau, increased in 2000. Our current dataset contains permit data for a subset of all FIPS places present in 1990 and 2000. The addition of new FIPS could be problematic if significant portions of critical habitat designated in recent years are contained in these areas and would otherwise appear in our comparisons (i.e., in incorporated areas). A quick comparison, however, reveals that only 17 of *all* 231 newly established FIPS contain habitat for recent designations. Only 2 of those 17 are incorporated areas that would have otherwise been included in our comparisons.

An important result occurs when we divide the sample into the two periods when critical habitat was first proposed: 1994-1995 and 2000-2001. The coefficient estimate for CHP_{it} is positive but insignificant for the regression run using the 1994-1995 sub-sample and is negative and significant when the 2000-2001 sample is used. Recall that the mean number of permits issued in 1990-1993 for the 2000-2001 CHP FIPS sub-sample was greater than the 1994-1995 CHP FIPS sub-sample, particularly on a per acre basis. Thus it appears that the proposal of critical habitat might have more of an impact on the FIPS that are more active in terms of development.

Overall, these results suggest that the proposal of critical habitat had a negative impact on the issuance of single-family building permits. Further, the impact is different depending on when critical habitat was proposed. This motivates the more formal structural analysis through the modeling of housing permits.

6.2 Regression Results

In this sub-section, we estimate the series of models as described in Section 5.2. The dependent variable is the natural log of single family building permits.[9] Regressors include the percent change in real median house prices, year dummies, variables that measure the potential impact of critical habitat designation, and other factors that might affect the number of permits issued. When the price data are added to the data set, we lose 24 FIPS due to missing values or reliability issues. Finally, the percent of the FIPS designated as critical habitat is missing for two FIPS. The final tally for the regression analysis is 359 FIPS and a total of 4,132 observations.

We first estimate Model 1 using FIPS-specific random effects. This allows us to include time invariant variables in the model. We include the natural logs of the population and area of

[9] Given that there are some observations with 0 permits (3.44%), we add 1 to the number of permits before taking the natural log.

the FIPS in 1990, the two regulation measures, and the three critical habitat indicators; CHP_{it}, CH_AREA_{it}, and CH_EVER_i. The results are given in column 1 of Table 6. Both the percent change in price and its lag are positive and significant (the coefficient estimates are 0.017 and 0.014, respectively). The contemporaneous price elasticity is 1.7 and the elasticity next period is 1.4. Thus a 1% increase in prices will lead to a 3.1% increase in permits over two years. Mayer and Somerville (2000b) estimate an annual supply elasticity of 3.7%. The size of the FIPS and its population both significantly affect the number of building permits: a 1% increase in area (population) leads to a 0.669% (0.162%) increase in building permits issued. The pro-growth index is positive and significant. An additional pro-growth regulation raises the number of permits by 6.5%. The estimated coefficient for the exclusionary growth index is actually positive but not significant.

The coefficient for CH_EVER_i is positive but not significant. The sign of this effect is surprising given that the mean of permits per acre prior to critical habitat designation was higher for non-CHP FIPS. Once this land is designated as critical habitat, the number of permits issued falls by 23.5% and this is significant at the 1% level.[10] The percent of the FIPS area that is designated as critical habitat has a distribution that is skewed right; the mean is 15.4 while the median is 6.9 and approximately 10% of the values are greater than 50%. We find that both CH_AREA_{it} and its square are individually significant at the 5% level. The coefficient estimate for the squared term is negative indicating that the number of permits decreases as the percent area that is designated as critical habitat increases. But the impact of CH_AREA_{it} is small as the number of permits decreases by only 1.7% if percent of the FIPS area that is designated as critical habitat is increased from 7% (median) to 50% (90^{th} percentile).

[10] When the dependent variable Y is specified in logs, the appropriate interpretation of the coefficient for a dummy variable X is that when X = 1, there is a 100*(exp(β)-1)% change in Y on average compared to when X = 0.

We next estimate Model 1 using fixed effects. We test for first-order serial correlation and find significant evidence that it exists ($\hat{\rho} = 0.37$, p-value<0.01). We then estimate Model 2 using fixed effects. Note that Model 2 includes a lagged dependent variable. The consistent estimator requires that Model 2 be first-differenced and that the differenced lagged dependent variable be instrumented. We use the second lag of the log of permits as our instrument. The results are given in column 2 of Table 6. Note that there is no evidence of first-order serial correlation in Model 2 (the p-value is 0.713) and that the lagged dependent variable is significant at the 1% level with an estimated coefficient of 0.420.

The coefficients for CHP_{it} and CH_AREA_{it} are both negative and individually insignificant at the 5% level but the p-value for the F-test that both coefficients are jointly zero is 0.006. The point estimate for the coefficient for CHP_{it} implies that, all else equal, once critical habitat is proposed, the number of permits falls by 20.5% in the short-run and by 32.6% in the long-run. Thus this provides evidence that the proposal of critical habitat has an economically large impact of the number of permits issued. As opposed to Model 1, the percent of the FIPS area that is designated as critical habitat does have an economically significant impact of the number of permits issued. For example, the number of permits decreases by 21.3% in the short-run and 33.8% in the long-run if the percent of the FIPS area that is designated as critical habitat is increased from 7% to 50%. It appears that CHD acts as a signal that development, in general, in that FIPS will be more costly and also further limits development as the percentage of the FIPS that is designated as critical habitat increases.

The presence of the median house price in the model raises concerns about endogeneity. Endogeneity of the current price change variable is unlikely since the issuance of a permit will not result in an actual new house until some point in the future. Mayer and Somerville (2000a) point out that the actual agreement about the price of the house at the purchase and sale is made 6-12 weeks prior to the listed date of the transaction and hence "The combination of a leading measure of supply and a lagged measure of prices makes endogeneity quite unlikely." (page 654) Despite this conclusion, Mayer and Somerville take two approaches towards mitigating the possible endogeneity bias. First, they leave out the current price change and second, they instrument for the current price change with the user cost of capital and the change in an index of employment in the MSA. They find that the instruments do not work well. In both cases, there is little change in the estimated coefficients or their standard errors for the regulation variables. We try leaving out the contemporaneous price change and instrumenting for the current price change with the lagged price change but neither have much impact on the estimated coefficient or its standard error for CHP_{it} and CH_AREA_{it}.

While the use of fixed effects is likely to alleviate much of the endogeneity bias associated with CHP_{it} and CH_AREA_{it} there is still the possibility that ΔCHP_{it} and ΔCH_AREA_{it} are correlated with $\Delta \varepsilon_{it}$. We try two approaches to reducing this possible bias. Fist we include a random trend in permits that is specific to each FIPS. If this trend is correlated with critical habitat designation and is left out of the model, the coefficients for CHP_{it} and CH_AREA_{it} will be biased in both the linear and first-differenced model. Upon differencing, the random trend results in the addition of fixed effects to the difference model. These fixed effects are not jointly significant and their inclusion has little impact on the estimated coefficient or its standard error for CHP_{it} and CH_AREA_{it}.

Next we use the annual rainfall and land-type variables to instrument for CHP_{it} and CH_AREA_{it}. Note that because Model 2 is estimated in first-differences, we are actually instrumenting for ΔCHP_{it} and ΔCH_AREA_{it}. We use annual rainfall, the first-difference of annual rainfall and the logs of the four land-type variables as instruments.[11] The F-statistic/p-value in the first stage regression for the test that the six instruments are jointly zero is 2.72/0.012 and 1.18/0.315 for ΔCHP_{it} and ΔCH_AREA_{it}, respectively. Thus these six instruments are not particularly good instruments for ΔCH_AREA_{it}. The results for the instrumental variables (IV) regression are given in column 3 of Table 6. The coefficient estimate for CHP_{it} has decreased in magnitude from -0.229 to -0.082 while the coefficient estimate for CH_AREA_{it} has increased in magnitude from -0.006 to -0.016. The two coefficients are no longer jointly significant. Given that there is little change in the coefficient estimates for the other variables, it should not be surprising that the Hausman test does not reject the null hypothesis of the exogeneity of ΔCHP_{it} and ΔCH_AREA_{it}. Thus the results in column 3 tend to be more believable.

Note that because we have six instruments, the IV regression is over-identified. This means that we can test for the validity of four of the instruments. We choose to assume that rainfall and the first difference in rainfall are exogenous. This allows us to test for the validity of the four land-type variables. First we run the IV regression using only rainfall and the first-difference in rainfall as instruments. We then regress the residuals from this regression on the exogenous variables from the IV regression and the four land-type variables. The F-test that the coefficients for the four land-type variables are jointly zero is not rejected at the 5% level. Thus this is evidence that the four land-type variables are exogenous.

Next, we allow the coefficient for CHP_{it} to vary both by the year since critical habitat was first proposed and by whether critical habitat was first proposed in the 1994-1995 period or the 2000-2001 period. We exclude CH_AREA_{it} from this regression to minimize the number of

[11] Since the four land-type variables can be zero, we add 1 before taking the log.

time-varying parameters in the regression so we can focus on whether the impact of CHD varies over time. The variables are denoted as *CHP9495-j*, j=0,1,…,8 and *CHP0001-k*, k=0,1,2 to indicate which period and how many years ago critical habitat was proposed (*CHP9495-0* refers to the 1994-1995 period and that critical habitat was proposed in that year). Since the data go through 2002, there are eight years after critical habitat was proposed in 1994 but only two periods after it was proposed in 2000. Further, to check to see if knowledge of the proposal of critical habitat existed prior to the proposal date, we include *CHP9495-M1, CHP9495-M2, CHP0001-M1*, and *CHP0001-M2*. These variables are 1 in each of the two years prior to the proposal of critical habitat. A negative coefficient estimate on these variables would be indicative of preemptive activity.

As seen in column 4 of Table 6, the variation in the coefficient estimates indicates that there is a different impact during the period that critical habitat was proposed and in the ensuing years. Note that the only one of these variables that is significant is *CHP0001-0*; the year of critical habitat proposal during the 2000-2001 period. The insignificance of the other variables is due, at least in part, to the fact that there are so few observations when these variables are 1. For example, there were only 23 FIPS in which critical habitat was proposed during the 1994-1995 period. When critical habitat was first proposed in either 2000 or 2001, there was a 28.6% decrease in the number of permits issued. In the following two years, the decrease was 20.9% and 25.8%. Whereas, when critical habitat was first proposed in either 1994 or 1995, there was only a 15.2% decrease in the number of permits issued. What is somewhat surprising is that this impact increased to 42.5% and 36.7% in the two years after critical habitat was proposed. After that, the impact was similar to the year that critical habitat was first proposed. Finally note that there is no impact on permit issuances in the two years prior to critical habitat proposal. This last result is not entirely surprising considering the circumstances of most California designations. Species in question typically occupy the proposed habitat and developers and others may already be aware of their presence due to protections afforded under other provisions of the Act. The proposal itself, however, through the delineation of specific boundaries and interpretation of that information by developers and municipalities is a significant event. Finally, these results suggest that we are controlling for the endogeneity of this event (mostly through the use of fixed effects).

7. Conclusion

We have conducted one of the first empirical analyses of the impact of critical habitat designation on the issuance of building permits for single family homes. Our data consist of the number of single family permits issued in close to 400 cities (FIPS) in California for the period 1990-2002. In our final dataset, critical habitat was proposed in 23 cities during the 1994-1995 period and in 98 cities during the 2000-2001 period. Since the U.S. Fish and Wildlife Service is required to consider economic impacts when designating critical habitat there is likely to be an endogeneity problem. First, we paired each FIPS in which critical habitat had been proposed with the closest FIPS where critical habitat had not been proposed. We find some evidence that supports the negative impact of critical habitat designation on the supply of housing permits in FIPS where designation took place in the 2000-2001 period but not in the 1994-1995 period. We plan to investigate further the reasons why this difference exists. Possible explanations will focus on differences in the characteristics of the FIPS, both physical and spatial, and the economic conditions in these two periods that might have differentially affected the housing market.

We then develop a theoretical model of permit supply based on the model of Mayer and Somerville (2000a, 2000b). Our best model in terms of controlling for the endogeneity of critical habitat designation is a partial adjustment model that includes FIPS-specific fixed effects and a lagged dependent variable. Here, we find that the proposal of critical habitat results in a 20.5% decrease in the supply of housing permits in the short-run and a 32.6% decrease in the long-run. It appears that CHD acts as a signal that development, in general, in that FIPS will be more costly. This is consistent with anecdotal evidence that cities where critical habitat has been designated tend to become more risk averse and hence more stringent in issuing new building permits regardless of whether or not they are for land in critical habitat designated areas. Further, the percent of the FIPS area that is designated as critical habitat does have an economically significant impact of the number of permits issued. For example, the number of permits decreases by 21.3% in the short-run and 33.8% in the long-run if the percent of the FIPS area that is designated as critical habitat is increased from 7% (median) to 50% (90th percentile).

We also find that the impact varies across the two periods in which critical habitat is designated and by the number of years relative to when critical habitat was first proposed. We do not find evidence that preemptive behavior since there is no significant change in the number of building permits in the two years prior to critical habitat proposal. Since critical habitat is a relatively new phenomenon, this analysis can only be enhanced by more data in the future.

This is the first step towards determining the impact of critical habitat designation on the housing market in California. The next step is to look at the general equilibrium impact of CHD on the issuance of building permits. This will capture any substitution of the lost development in CHP FIPS with additional new development in the non-CHP FIPS. The final step is to translate the change in the supply of new building permits into an impact on the overall price of housing in order to determine the full costs of critical habitat designation. We leave these two steps for future research.

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Figure 1. Approximate Extent of Designated Critical Habitat in California

Figure 2. FIPS Places included in Empirical Analysis

Table 1
Federally Listed Species and Critical Habitat Designations in California

Category	Number
Total number of species	82
Total number of critical habitat designations	68
Number of species for which GIS data are available for designations	39
Number of species habitat designations that intersect with FIPS places	26
Source: USFWS Website (endangered.fws.gov)	
Note: the number of critical habitat designations is not equivalent to the number of listed species. For example, several species can be included in one designation or individual species can be found in separate designations that occupy the same land.	

Table 2 - Variable Definitions and Summary Statistics						
Variable	Definition	N Obs	Mean	Std Dev	Minimum	Maximum
PERMITS (S)	Single family permits	4811	152.33	302.11	0	3227
CHP	1 if critical habitat proposed in current or prior year, 0 otherwise	4811	0.09	0.29	0	1
CH_EVER	1 if critical habitat ever proposed, 0 otherwise	4811	0.32	0.47	0	1
CH_AREA	Percent FIPS area designated as critical habitat when CHP=1, 0 otherwise	4785	1.62	8.72	0.00	91.49
PRICE	Median house price in 1,000s of 1990 dollars	4687	171.19	121.55	24.19	2520.69
AREA	Land area of FIPS in 1990 in 1,000s of acres	4811	10.22	22.03	0.21	303.34
POPULATION	Population in 1990 in 1,000s	4811	56.97	198.72	0.19	3485.40
HOUSE UNITS	Number of housing units in 1990 in 1,000s	4811	21.25	74.14	0.09	1299.96
GROW	Pro growth index	4811	2.49	2.30	0	9
EXCLUDE	Exclusionary growth index	4811	8.15	6.48	0	58
RAINFALL	Annual precipitation in inches	4811	18.42	12.58	0.00	102.49
FOREST	Acres characterized by tree cover generally greater than 6 meters in height	4811	380.07	1411.10	0.00	19673.23
SHRUBLAND	Acres of areas characterized by woody vegetation less than six meters tall	4811	1841.95	6328.05	0.00	76468.08
WATER	Acres of areas of open water	4811	82.46	525.41	0.00	8407.19
WETLAND	Acres of areas where soil or substrate is periodically saturated with or covered with water	4811	8.99	42.26	0.00	404.24

Table 3 - Comparison of CHP FIPS and Non-CHP FIPS							
	CHP FIPS				Non-CHP FIPS		
Variable	All	1994-1995	2000-2001	p-value	All	Neighbor	p-value
POPULATION (in 1990)	103.348	112.69	63.542	0.531	32.804	35.340	0.030
HOUSE UNITS (in 1990)	38.896	42.508	23.507	0.516	12.097	13.166	0.028
AREA (in 1990)	17.598	18.937	11.889	0.389	6.397	7.057	0.002
POPULATION/AREA (in 1990)	5.292	5.340	5.086	0.735	6.207	6.601	0.050
HOUSE UNITS/AREA (in 1990)	2.018	2.057	1.849	0.470	2.258	2.371	0.112
PRICE, 1990-1993	190.255	158.845	199.015	0.000	170.809	177.157	0.067
PERMITS, 1990-1993	188.94	178.45	233.32	0.095	97.942	126.245	0.000
PERMITS/AREA, 1990-1993	0.013	0.011	0.022	0.000	0.018	0.018	0.003
GROWTH	2.736	2.847	2.261	0.259	2.261	2.067	0.014
EXCLUDE	9.579	9.724	8.957	0.646	7.170	7.463	0.009

Table 4: Matched Pair Results				
Year	Number	P Neighs >	pct Diff	P-value
1994	13	46.15	32.89	0.38
1995	23	47.83	34.70	0.28
1996	23	43.48	10.11	0.82
1997	23	39.13	31.78	0.41
1998	23	34.78	42.01	0.32
1999	23	34.78	38.78	0.40
2000	86	44.71	10.46	0.58
2001	121	51.69	-45.35	0.06
2002	120	51.69	-43.70	0.05
Distance between pairs less than or equal to 2				
1994	11	36.36	37.42	0.35
1995	20	45.00	46.62	0.14
1996	20	45.00	5.85	0.90
1997	20	35.00	43.98	0.26
1998	20	35.00	61.52	0.14
1999	20	35.00	60.76	0.18
2000	72	41.67	11.15	0.61
2001	99	48.98	-34.44	0.16
2002	98	50.00	-39.73	0.11
Distance between pairs less than or equal to 1				
1994	8	25.00	67.98	0.10
1995	15	40.00	68.12	0.04
1996	15	26.67	70.41	0.06
1997	15	26.67	60.58	0.12
1998	15	26.67	76.85	0.09
1999	15	33.33	75.29	0.13
2000	48	39.58	19.11	0.49
2001	58	48.28	-58.46	0.13
2002	58	48.28	-51.16	0.16
sf - sf(-1)				
1994	12	76.92	-136.01	0.10
1995	10	70.00	-2032.21	0.41
2000	63	54.84	-39.18	0.64
2001	35	71.43	-76.90	0.59
sf(+1)-sf(-1)				
1994	12	69.23	-86.02	0.14
1995	10	40.00	-120.75	0.31
2000	63	53.23	-212.14	0.16
2001	35	51.43	60.47	0.90

Table 5 – Matched Pair Regression Results					
	coef	se	p-value	num	R-sq
All Observations	-0.002	0.002	0.077	898.000	0.014
Distance <= 1 Mile	0.002	0.002	0.419	494.000	0.014
Only Year Proposed	-0.005	0.003	0.025	240.000	0.025
Only Year Proposed and Distance <= 1 Mile	-0.003	0.004	0.121	130.000	0.029
1994-5	0.008	0.002	0.500	394.000	0.052
2000-1	-0.009	0.003	0.000	504.000	0.026
1994-5:Distance <= 1 Mile	0.015	0.003	0.500	248.000	0.113
2000-1:Distance <= 1 Mile	-0.011	0.003	0.000	246.000	0.040
1994-5:Only Year Proposed	0.005	0.005	0.414	46.000	0.119
2000-1:Only Year Proposed	-0.008	0.004	0.009	194.000	0.022
1994-5:Only Year Proposed and Distance <= 1Mile	0.014	0.006	0.497	32.000	0.276
200-1:Only Year Proposed and Distance <= 1 Mile	-0.008	0.004	0.018	98.000	0.033

Table 6 - Regression Results				
Variable	Model 1 – RE (1)	Model 2 – FE (2)	Model 2 – IV (3)	Model 2 – FE (4)
$\ln S_{-1}$		0.420**	0.421**	0.422**
		(0.076)	(0.096)	(0.077)
ΔlnPRICE	0.017**	0.004*	0.004	0.004*
	(0.002)	(0.002)	(0.002)	(0.002)
$\Delta \ln PRICE_{-1}$	0.014**	-0.0005	-0.0006	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
lnAREA	0.669**	0.319	0.291	0.327
	(0.064)	(0.189)	(0.399)	(0.190)
lnPOPULATION	0.162*			
	(0.064)			
GROW	0.065*			
	(0.028)			
EXCLUDE	0.012			
	(0.010)			
CH_EVER	0.150			
	(0.131)			
CHP	-0.268**	-0.229	-0.082	
	(0.084)	(0.129)	(1.873)	
CH_AREA	0.016*	-0.006	-0.017	
	(0.007)	(0.005)	(0.120)	
$CH\_AREA^2/100$	-0.020*			
	(0.009)			
CHP9495-M2				0.05
				(0.229)
CHP9495-M1				0.004
				(0.228)
CHP9495-0				-0.165
				(0.227)
CHP9495-1				-0.553
				(0.324)
CHP9495-2				-0.458
				(0.400)
CHP9495-3				-0.192
				(0.462)
CHP9495-4				-0.166
				(0.515)
CHP9495-5				-0.108
				(0.565)
CHP9495-6				0.07
				(0.610)
CHP9495-7				-0.293
				(0.653)

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