Unintended Effects of Environmental Policies: The Case of Urban Growth Controls and Agricultural Intensification

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ABSTRACT *When environmental policies do not control decision-making on all margins, they can have unintended effects on the environment. We examine effects of urban growth boundaries (UGBs) on agricultural intensification. A primary goal of a UGB is to preserve open space outside the boundary; however, by eliminating the future rent stream from development, UGBs encourage landowners to adopt more capital-intensive agricultural uses. We empirically estimate UGB effects on intensification rates in Ventura County, California. Difference-in-differences estimates reveal that UGBs increased intensification rates by 16–21 percentage points. In Ventura County, policies designed to preserve open space accelerated its loss and increased agricultural externalities* (JEL Q15, Q58).

1. Introduction

Environmental policies can be used to address externality and public goods problems but may also have unintended consequences. Examples abound in the literature. Domestic subsidies for biofuels create incentives for land conversion elsewhere that may increase greenhouse gas emissions overall (Searchinger et al. 2008). Similarly, conservation policies for agricultural land and forestland can raise commodity prices such that additional lands are brought into crop production or harvested, working against the conservation goal (Sohngen, Mendelsohn, and Sedjo 1999; Wu 2000; Alix-Garcia, Shapiro, and Sims 2012). Government investment in flood control has been shown to induce conversion of wetlands (Stavins and Jaffe 1990), and open-space preservation can generate amenities that raise the local demand for urban development (Wu and Plantinga 2003). Policies that encourage investment in energy efficiency lower the cost of energy services, thereby leading to increased energy use (Gillingham et al. 2013). Finally, subsidies for pollution control can result in excess entry by firms that increases total output by the polluting industry (Goulder and Parry 2008).

In all of these examples, the environmental policies have unintended consequences because they affect decision-making on one margin but leave other margins uncontrolled. As such, there are market adjustments induced by the policies that increase the externality targeted for reduction and, perhaps, nontargeted externalities as well. In an example discussed by Claassen et al. (2001), payments to farmers who apply nitrogen at reduced rates have the unintended effect of increasing soil erosion. The nitrogen subsidy makes it profitable for farmers to expand crop production into less productive areas susceptible to soil erosion. This has the unintended effect of increasing the supply of agricultural crops, which leads to more soil erosion. Clearly, one solution is to use multiple incentives to influence decision-making on many margins (Goulder and Parry 2008). However, as the above examples suggest, this may be difficult to do in practice or policy makers may be unaware ex ante of the additional effects of a policy.

In this article, we evaluate the effects of urban growth controls in Ventura County, California, on agricultural land use decisions. Communities across the United States have

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turned increasingly to urban growth boundaries (UGBs) and other containment policies in order to shape the spatial structure and environmental character of urban areas. By 2000, some form of urban containment policy had been implemented in 23% of census-designated urban areas in the United States (Wassmer 2006). This trend has been particularly prominent in California, where 37 growth-boundary measures appeared on ballots between 1986 and 2006. Of 25 proposed between 1990 and 2000, only one was defeated (Fulton et al. 2002). In the late 1990s, Ventura County voters approved a series of initiatives requiring UGBs around seven municipalities and voter approval of any new development (e.g., housing construction) outside UGBs. The goal of these initiatives was to preserve open space and agricultural lands outside existing urban areas (the set of initiatives are known collectively as Save Open Space and Agricultural Resources, or SOAR).

The central result of this article is that urban growth controls can have the unintended effect of encouraging the intensification of agricultural lands. Agricultural intensification refers to an increase in input use on a fixed land base. Intensification can have significant effects on environmental quality when it increases water and chemical use in agriculture, particularly when these inputs are unregulated.[1] The consequences of intensification are especially acute in Ventura County, where aquifers are in a chronic state of overdraft—by more than 50% of safe yield, on average (FCGMA 2015)—and where per-acre pesticide application is the highest of any county in California (CDPR 2015). The agricultural pesticides used in Ventura County include known toxins and carcinogens, and they are often applied in close proximity to human populations. In Ventura County, the adoption of UGBs had the effect of eliminating the option for landowners to convert their land to developed uses in the future. Once the development option was eliminated, the marginal value of capital and other inputs in agriculture increased because the investment pays out over a longer time horizon. We develop a theoretical model to show that, under standard conditions, landowners increase the capital and input intensity of agricultural production following the adoption of UGBs.

We also conduct an empirical analysis of the effects of Ventura County UGBs on agricultural intensification, measured as the adoption of irrigation. The Ventura County UGBs have features that distinguish them from UGBs in California and elsewhere and make them an appealing focus of empirical analysis.[2] First, the Ventura County UGBs are unusually restrictive, which allows for sharp tests of our hypotheses. The SOAR initiatives stipulate that countywide voter approval is required to move a boundary or make any zoning change outside a UGB. In practice, this has had the effect of halting new development outside the boundaries.[3] Second, the way in which the UGBs were designated provides a kind of natural experiment that mitigates potential bias from endogenous placement of the boundaries. Previous UGB studies can be criticized on the grounds that UGB locations are likely to be correlated with unobserved determinants of property prices or other outcome variables (Severen and Plantinga 2018).

Using spatially detailed land use data, we find that for parcels near the Ventura County UGBs, the 10-year intensification rate was approximately 30% in the period following UGB adoption (specified in our analysis as either 1994–2010 or 2000–2010). However, there may have been other factors contributing to this change, such as an increase in demand for intensively produced commodities that is unrelated to UGBs. Therefore, we include data for neighboring Santa Barbara County, which did not implement UGBs, and estimate the effects using a difference-in-differences estima-

[1] Of course, the alternative to intensification—more urban development—can also have negative environmental effects. We are not arguing that intensification is a worse outcome but rather that it can be at odds with the goal of preserving undeveloped land.

[2] Although UGBs have a common objective of controlling where urban development occurs, there are important differences in how they are implemented, including the extent to which development is allowed outside the boundary.

[3] In contrast, UGBs in Sonoma County and in the Willamette Valley of Oregon allow for low-density residential development outside boundaries (Newburn and Berck 2006; Dempsey and Plantinga 2013).

tor. We argue that Santa Barbara County is an appropriate counterfactual for Ventura County based on similar agricultural production and the fact that potential differences between the counties attenuate the measured UGB effects. Moreover, during the period prior to the policy change (specified as 1984–1994), rates of agricultural intensification were nearly identical in the two counties.

As mentioned above, a second threat to identification is that the placement of UGBs could be correlated with factors influencing the likelihood of intensification. To mitigate this concern, we exploit a feature of land use planning in California referred to as the Sphere of Influence (SOI) line. State law requires that regional planning commissions, called Local Agency Formation Commissions (LAFCos), designate SOI lines around all cities. An SOI indicates a city's probable future boundary and thus demarcates the transition from urban to rural land uses. However, SOIs are less stringent than the Ventura County UGBs in that voter approval is not required to adjust their location or for urban development to occur beyond the SOI. SOIs were designated in Ventura and Santa Barbara Counties prior to the adoption of UGBs in Ventura County, and when the Ventura County UGBs were designated, they were placed on the existing SOI lines. We compare agricultural parcels just outside the SOI lines in Ventura and Santa Barbara Counties, which effectively controls for the placement of the UGBs. The identifying assumption is that the SOI lines in the two counties were designated in a similar way with respect to the likelihood of intensification. We provide justification for this key assumption.

2. Previous Literature

There have been numerous economic studies examining the effects of UGBs and related containment policies on housing and land markets. The results of these studies are mixed. Some authors find no effects of UGBs on housing market outcomes (Pendall 1999, 2000; Jun 2004; Cho, Chen, Yen, and Eastwood 2006; Cho, Omitaomu, Poudyal, and Eastwood 2007), consistent with the idea that regulation follows the market (Quigley and Rosenthal 2005). Other authors have found significant effects of UGBs on land prices (Knaap 1985; Grout, Jaeger, and Plantinga 2011), housing prices (Phillips and Goodstein 2000; Cho, Chen, and Yen 2008), urban area size (Wassmer 2006), rates of land conversion to urban uses (Kline and Alig 1999; Cunningham 2007; Dempsey and Plantinga 2013), residential construction (Jackson 2016), and relative prices for urban and exurban lands (Bigelow and Plantinga 2017). Newburn and Berck (2006) study how access to municipal services, which in their study region is closely related to UGB designations, affects the density of development. In related work, Newburn and Berck (2011) simulate development patterns with and without UGBs, finding that the growth controls reduce suburban development but have limited effects on exurban development. To our knowledge, no studies have examined the effects of UGBs on agricultural decisions outside the boundaries.

The environmental consequences of agricultural intensification are well known (Matson et al. 1997; Tilman et al. 2002) and include such effects as increased erosion, diminished soil fertility, air and water pollution, and impacts on human health and climate. Other studies have examined the relationship between agricultural intensification and urbanization and found mixed results. In New Jersey, suburbanization is shown to be associated with lower capital use in agriculture but paradoxically increased production of intensive crops (Lopez, Adelaja, and Andrews 1988). In the northeastern United States, a positive association is found between urbanization and small-scale intensive farming (Lockeretz 1988). In an application to the western United States, the number of input suppliers, which could be an indicator of intensification, increases with urban development and population density at low levels of these variables, but it decreases at high levels (Wu, Fisher, and Pascual 2011). Finally, in China, agricultural land use intensity decreases with urban expansion (Jiang, Deng, and Seto 2013). If high urbanization rates today indicate that future demand for urban land is satisfied, then urbanization should have a similar effect on agricultural land use as a UGB.

Our theoretical model, detailed below, is based on an earlier study of land use intensity by Capozza and Li (1994). The authors consider the optimal use decision by a landowner when future returns to two alternative uses are stochastic. The landowner chooses the time to convert from the first to the second use as well as the capital intensity of the second use. This model extends the earlier work by Capozza and Helsley (1990) showing that uncertain future returns to urban development delay the optimal development time. Intensity further delays development decisions because there is an option value associated with delaying the irreversible capital investment decision. Capozza and Li (2002) show that intensity creates incentives to delay development even when future returns to development are certain. If development rents are rising, it may be optimal to forgo revenues from developing today in order to gain additional revenues from development at a higher intensity in the future.

3. Theory of Agricultural Land Use

The theoretical model examines how the elimination of future development rents affects intensive margin choices in agriculture. We adapt the Capozza and Li (1994) model to our problem by allowing landowners to choose the level of capital investment in agriculture and by treating future development rents as deterministic. The latter simplification affects the optimal timing of development but does not alter the qualitative effect of eliminating the future rent stream from development. In a competitive land market, the price per acre of agricultural land in time t with attributes $\mathbf{x}$ is given by

$$P_t(t^*,\mathbf{x},k^*) = \int_t^{t^*} q(k^*)A(s,\mathbf{x})e^{-r(s-t)}ds - ck^* + gk^* e^{-r(t^*-t)} + \int_{t^*}^{\infty} R(s,\mathbf{x})e^{-r(s-t)}ds - Ce^{-r(t^*-t)}, \qquad [1]$$

where t^* and k^* are the development time and the level of capital investment, respectively. The capital-land ratio or capital intensity, $q(k)$, scales per-acre agricultural rents $A(s,\mathbf{x})$, which are assumed to be strictly positive. We further assume $q_k > 0$ and $q_{kk} < 0$; thus, capital investment increases agricultural rents but at a diminishing rate. For simplicity, we assume that the landowner makes a one-time choice of capital k^* in time t and normalize the initial capital stock to zero.[4] Capital has a per-unit cost c and a per-unit salvage value of g at the time t^* when the land is developed. The per-acre rents from future development are $R(s,\mathbf{x})$, and the costs of development are C. The discount rate is r.

A profit-maximizing landowner chooses the development time and level of capital to maximize the value of the land parcel. Thus t^* and k^* satisfy the following first-order conditions:[5]

$$\frac{\partial P_t}{\partial t^*} = q(k^*)A(t^*,\mathbf{x}) - rgk^* - R(t^*,\mathbf{x}) + rC = 0$$

$$\frac{\partial P_t}{\partial k^*} = q'(k^*)\int_t^{t^*} A(s,\mathbf{x})e^{-r(s-t)}ds - c + ge^{-r(t^*-t)} = 0. \qquad [2]$$

Eliminating the option of future development changes equation [1] to

$$P_t(\mathbf{x},k^*) = \int_t^{\infty} q(k^*)A(s,\mathbf{x})e^{-r(s-t)}ds - ck^*. \qquad [3]$$

Now, capital is the only choice variable, with the following corresponding first-order condition:

$$\frac{\partial P_t}{\partial k^*} = q'(k_\infty^*)\int_t^{\infty} A(s,\mathbf{x})e^{-r(s-t)}ds - c = 0, \qquad [4]$$

where k_∞^* denotes the solution with no development option. Given the concavity of $q(k)$, a sufficient condition for elimination of future

[4] Our empirical application involves a change from grazing to irrigated agriculture. This entails the adoption of irrigation infrastructure as well as changes in labor and other capital equipment. For simplicity, we represent all of these inputs with the scalar k^*.

[5] The second-order condition requires that $P_{t^*t^*} = qA_{t^*} - R_{t^*} < 0, P_{k^*k^*} = q''\int_t^{t^*} A(s,\mathbf{x})e^{-r(s-t)}ds < 0$, and $P_{t^*t^*}P_{k^*k^*} > P_{t^*k^*}^2$. The first condition says that development rents must be increasing faster than agricultural rents at the time of development, and the second condition is satisfied because of the concavity of $q(k)$ and $A(s,\mathbf{x}) > 0$. The third condition holds with restrictions on functional forms and parameters in our model.

development rents to increase capital investment is

$$q'(k_\infty^*)\int_t^\infty A(s,\mathbf{x})e^{-r(s-t)}ds >$$
$$q'(k_\infty^*)\int_t^{t^*} A(s,\mathbf{x})e^{-r(s-t)}ds + ge^{-r(t^*-t)}. \quad [5]$$

When equation [5] holds, the quantity of capital, k^*, that satisfies the first-order condition in equation [2] is less than the quantity, k_∞^*, that solves equation [4]. The condition in equation [5] says that a unit of capital with marginal capital intensity $q'(k_\infty^*)$ is worth more if left in place than if salvaged; that is, capital investment involves sunk costs.[6] When the rent stream from future development is extinguished, the landowner has a greater incentive to invest in capital-intensive agriculture because the benefits from the investment will be realized over a longer time horizon.

A second implication of the model is that intensification in agriculture will vary over space. To see this, suppose that development rents are higher close to the urban center, which is a standard result from urban spatial theory (e.g., Solow [1973]). We can represent this in our model by assuming that distance to the urban center is included in the vector of land attributes **x** and that development rents are decreasing in x; that is, $R_x(t,\mathbf{x}) < 0$. Applying Cramer's rule to the first-order conditions in equation [2], we obtain

$$\frac{dk^*}{dx} = \frac{-R_x(t^*,\mathbf{x})[q'(k^*)A(t^*,\mathbf{x}) - rg]}{|\mathbf{J}|}, \quad [6]$$

where $|\mathbf{J}|$ is the determinant of the Jacobian matrix, which is positive by the second-order condition. The sign of $\frac{dk^*}{dx}$ is positive if $q'(k^*)A(t^*,\mathbf{x}) - rg > 0$. This inequality can be rewritten as $q'(k^*)\frac{A(t^*,\mathbf{x})}{r} > g$, where $\frac{A(t^*,\mathbf{x})}{r}$ is the present discounted value of an infinite stream of rents $A(t^*,\mathbf{x})$. It says that the marginal value of capital at time t^* agricultural rents exceeds the salvage value, which seems likely to hold with sunk costs of capital investment.[7] The inequality $\frac{dk^*}{dx} > 0$ implies that the initial level of capital investment is lower for parcels closer to the urban center. When the development option is removed, all parcels adopt the same level of capital conditional on x (equation [4]).[8] Thus, the *change* in capital investment will be higher for parcels just outside the UGB than for those farther away. In the empirical application below, we test whether intensification rates vary in this way.

4. Empirical Application

Land Use in Ventura and Santa Barbara

Overview

Ventura County lies north of Los Angeles along the Pacific Ocean (Appendix Figure A1). It contains a mix of medium- and small-sized urban areas (e.g., the cities of Ventura and Ojai, respectively), intensive and nonintensive agriculture, and public land, especially the Los Padres National Forest. Intensive agriculture includes a diverse mix of irrigated vegetable and fruit crops.[9] Nonintensive agriculture (representing about 65% of all private agricultural land) mostly involves cattle grazing on nonirrigated rangeland. The distinction between irrigated and nonirrigated agricultural land is important for this study, as we define intensification as the adoption of irrigation (more details are provided below, in the data section).

Santa Barbara County borders Ventura County to the northwest and includes a similar mix of urban areas (e.g., the cities of Santa Barbara and Santa Maria), agriculture, and public lands. As in Ventura County, intensive agriculture involves a similar mix of irrigated vegetable and fruit crops, and nonintensive agriculture (representing about 80%

[6] For example, installation of irrigation systems for agriculture requires labor expenditures, which cannot be recovered if the capital is redeployed in another location. The presence of sunk costs implies that current profits will have asymmetric effects on decisions to invest in and salvage capital, as in Dixit (1989).

[7] It can be shown that equation [5] implies a similar condition: $q'(k_\infty^*)\int_{t^*}^\infty A(s,\mathbf{x})e^{-r(s-t^*)}ds > g$.

[8] With no development option, land prices no longer vary with distance to the urban center, although they may vary with other attributes such as soil quality.

[9] See Ventura County, "Crop Report Archive," https://www.ventura.org/agricultural-commissioner/crop-reports/ (accessed August 28, 2019).

of private agricultural land) is dominated by cattle grazing.[10] As shown in Appendix Figure A1, in 2001 when the Ventura County UGBs were adopted, both counties had urban areas in close proximity to cultivated cropland as well as urban areas bordered by nonintensive land uses (e.g., herbaceous and shrub/scrub land covers).[11] One difference between the two counties is the recent growth in wine-grape production in Santa Barbara County that did not occur in Ventura County. Santa Barbara's wine-grape acreage increased by 55% between 2000 and 2010, although it accounted for only about 17% of total irrigated acreage by the end of the period.[12] We do not have data on which lands were converted to wine-grape production, but we emphasize that the expansion in grape production does not involve intensification if the converted lands were previously irrigated.

Agriculture is heavily dependent on groundwater in both Ventura and Santa Barbara Counties, yet there are differences between the counties in access to groundwater. In Ventura County, four of the five largest groundwater basins limited extraction by agricultural users during the study period. The Oxnard, Pleasant Valley, and Las Posas Basins (known collectively as the Fox Canyon Basins) as well as the Santa Paula Basin adopted groundwater management policies in the 1990s, capping total groundwater extraction basin-wide. In the Santa Paula Basin, authority to restrict pumping was established through an adjudication; pumpers are limited to a fixed allocation but may buy unused allocation from another pumper in an informal water market. In the Fox Canyon Basins, authority to restrict pumping was established through state legislation; pumpers are limited to a fixed allocation and pay a punitive surcharge for exceeding that allocation. These limits on total extraction affect approximately 43,900 acres of farmland in the Fox Canyon Basins (FCGMA 2015) and 10,700 acres in the Santa Paula Basin (John Lindquist, pers. comm. 2020).

In contrast, there were no significant restrictions on groundwater pumping by agricultural water users in Santa Barbara County. Groundwater pumping in six of the eight groundwater basins designated by the California Department of Water Resources was unregulated throughout the study period. The two other basins underwent adjudication of water rights, but the resulting judgments did not restrict agricultural pumping. The Santa Maria Valley Groundwater Basin, located in the northwest part of the county, adjudicated water rights in 2008, near the end of our study period, but the resulting judgment did not impose a cap on groundwater extraction by agricultural pumpers.[13] The Goleta Groundwater Basin, a small basin west of the city of Santa Barbara, also underwent adjudication, with a judgment entering into force in 1989. The judgment established an overlying right to 351 acre-feet per year of pumping by agricultural water users, but it did not prohibit agricultural pumpers from exceeding this allocation (Ayres, Edwards, and Libecap 2018). To the extent that intensification could have been limited by water access during our study period, the effect would have been more pronounced in Ventura County. As discussed in the identification section below, restrictions on water use in Ventura County would attenuate the measured effects of the Ventura County UGBs.

Urban Growth Controls

The UGBs in Ventura County are among the most stringent urban containment policies adopted in the United States. Passed by ballot initiatives between 1998 and 2000, the county and seven of the county's 10 municipalities adopted a set of policies known collectively

[10] See Santa Barbara County, "Crop Report Archive," https://countyofsb.org/agcomm/cropReportArchive.sbc (accessed August 29, 2019).

[11] Appendix Figure A1 uses data from the National Land Cover Database, which defines herbaceous as areas dominated by herbaceous vegetation, not subject to intensive management, and usable for grazing. Shrub/scrub are areas dominated by shrubs that account for 20% or more of total vegetation.

[12] See Santa Barbara County, "Crop Report Archive," https://countyofsb.org/agcomm/cropReportArchive.sbc (accessed August 29, 2019).

[13] Rather, the adjudication established that the cities of Santa Maria and Guadalupe had not acquired a prescriptive right to pump groundwater.

as SOAR.[14] SOAR implements UGBs around seven municipalities, protecting more than 600,000 acres of open space and agricultural land from development. The SOAR movement in Ventura County traces its roots to a ballot measure passed in the city of Ventura in 1995. That measure (also known as SOAR but meaning Save Our Agricultural Resources) was advanced by neighborhood residents opposed to a land swap between the city of Ventura and a developer that would have converted agricultural land to housing (Fulton et al. 2002). Modeled on a Napa County ordinance that had recently survived a constitutionality challenge in the California Supreme Court,[15] the measure requires voter approval of any change in zoning designation from nonurban to urban use within the city. It targets islands of agricultural land within the city limits and protects those areas from development.

The city of Ventura's urban growth restrictions were the catalyst for eight subsequent ballot measures (seven municipal measures and a countywide measure) that established the Ventura County UGBs.[16] SOAR has two unique characteristics compared to growth restrictions imposed elsewhere. First, it does not provide a mechanism for automatically expanding UGBs to accommodate future growth, as is the case with UGBs in Oregon (Grout, Jaeger, and Plantinga 2011). In addition, any zoning change permitting future development outside the UGBs must be approved by a majority vote of the county electorate. Typically, local planning boards decide on zoning changes. For example, in Santa Barbara County, the County Board of Supervisors can elect to rezone land from agriculture to development.[17] In November 2016, Ventura County voters passed ballot measures extending the existing SOAR boundaries unamended until 2050. Because voters have consistently struck down zoning-change measures, opportunities for future development outside UGBs have effectively been eliminated.[18]

Second, the locations of UGBs follow existing civic boundaries (SOI lines), as they existed at the time SOAR was passed.[19] SOIs are designated by LAFCos, countywide planning agencies with the mission of discouraging urban sprawl and preserving agricultural land. LAFCos were originally created by a series of laws passed by the California state legislature over the period 1963–1985 that had the broad goal of coordinating planning at a regional level. A consolidated LAFCo Act, passed in 1985, clarified the regulatory and planning authorities of the LAFCos. As a regulatory agency, they are commissioned to discourage urban sprawl. LAFCos must consider the effect that any proposal has on existing agricultural land and must guide development toward existing vacant urban land. As a planning agency, they are charged with determining and updating, at least every five years, the location of each city's SOI line. An SOI is a planning boundary outside a city limit that designates the city's probable future boundary. Although SOI lines are designated on a local level, they must address a common set of goals set forth under state law. This fea-

[14] The city of Ventura adopted growth controls earlier, as explained below. The two cities in Ventura County that did not approve growth boundaries are Port Hueneme and Ojai. Port Hueneme is completely surrounded by the city of Oxnard to the north, the Pacific Ocean to the west and south, and Naval Base Ventura County to the east, and thus it cannot undergo urban expansion. The city of Ojai has a small, suburban municipal core surrounded by semirural development (so-called rancheros). It lacks a clear agriculture-urban interface like the other cities considered in this study.

[15] De Vita *v.* County of Napa, 9 Cal. 4th 763 (1995).

[16] The original city of Ventura measure requires voter approval for land use changes within the city limit, whereas the eight subsequent SOAR ballot measures require voter approval for land use changes outside UGBs. Our study focuses on agricultural intensification outside UGBs. Because the city of Ventura also protects agricultural land inside its UGB, we exclude lands surrounding the city of Ventura from our sample.

[17] With the exception of cannabis cultivation, which has only recently expanded in Ventura and Santa Barbara Counties, neither county regulates land use decisions within agriculture.

[18] We reviewed all of the ballot measures in Ventura County since the adoption of UGBs. Other than a few minor changes in zoning designations in 1999 to bring specific parcels into compliance with the county's General Plan, no major developments have been approved. Indeed, the only significant proposal was in 2006 for a 1,680-unit development outside Moorpark. Voters rejected the proposal by a three-to-one majority.

[19] An exception is the small city of Santa Paula, which initially set its UGB inside of the SOI. The UGB was later moved to align with the SOI.

ture of SOI lines is important for our identification strategy, as discussed below. Compared to the UGBs in Ventura County, SOI boundaries are much less stringent in that they can be adjusted by a simple majority of the members of the presiding LAFCo, and it is possible for development to occur outside an SOI boundary. Appendix Figure A4 shows the locations of Ventura County UGBs and Santa Barbara County SOIs.

What led to the adoption of UGBs in Ventura County but not in Santa Barbara County? According to Fulton et al. (2002), population growth and urban sprawl are two important determinants of the local adoption of growth management policies. Population growth rates in the two counties have been similar in recent decades,[20] but they were considerably higher in Ventura County prior to the adoption of UGBs. Although the populations of the two counties were almost identical in 1940, by 1980 Ventura County's population had increased to 529,000 persons (a 6.6-fold increase), whereas Santa Barbara County's population had grown only to 299,000 persons (a 3.2-fold increase). Fulton et al. (2002) note that this rapid growth in Ventura County's population resulted in leapfrog development and a patchwork of subdivisions and agricultural land. Urban development in Santa Barbara County, at least in the southern portion adjacent to Ventura County, is highly constrained by the Pacific Ocean to the south and the Los Padres National Forest to the north. These differences in population growth and development patterns can help explain why Ventura County adopted UGBs in the 1990s and Santa Barbara County did not, but they could also produce differences in incentives for agricultural intensification, potentially invalidating our use of Santa Barbara County as a counterfactual for Ventura County. We present below a parallel trends test that explicitly addresses this concern.

Agricultural Intensification

Following the implementation of UGBs, water use increased in Ventura County. Between 1998 and 2010, the total area of irrigated land in Ventura County increased by about 6%.[21] This increase was accompanied by a large increase in the acreage in strawberry production (Figure 1). From 1995 to 2010, total harvested acres of strawberries increased by 156%. Compared to neighboring Santa Barbara County, the change in strawberry acreage was large in magnitude. As illustrated in Figure 1, despite having approximately the same number of acres in strawberry production prior to the implementation of UGBs in Ventura County, Santa Barbara County was quickly surpassed by Ventura County. Growth in strawberry acreage was part of a statewide trend, but Figure 1 shows that the largest gains after 1995 occurred in Ventura County. The post-1995 trend in Santa Barbara County is similar to the trend in Monterey County and shows larger acreage gains than in Santa Cruz and San Luis Obispo Counties.

Berries are among the most water- and chemical-intensive crops grown in California. A typical grower will use on average 4.0 acre-feet of water per acre to grow berry crops compared to just 1.8 acre-feet of water per acre for citrus and avocado trees.[22] It is reasonable to assume that as berry acreage increased, pumping in heavily groundwater-dependent Ventura County increased. With the net addition of 7,000 acres of irrigated land, agricultural intensification in Ventura County likely led to an additional 28,000 acre-feet of groundwater extraction, compared to the case with no intensification. That is an increase in pumping equivalent to the average annual water use of over 50,000 California households. Increased groundwater pumping likely exacerbated existing externalities since extraction is imperfectly regulated in Ventura County (see above discussion of groundwater).

Intensification is also likely to have increased pesticide applications. In 2010, Ventura County averaged 72 pounds of ac-

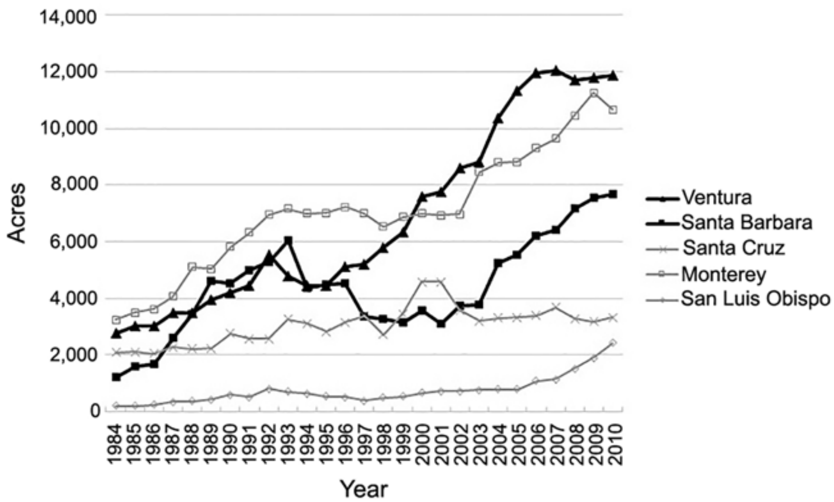
[20] Between 1990 and 2018, the total population increased 27% in Ventura County and 21% in Santa Barbara County.

[21] California Department of Water Resources, "Agricultural Land & Water Use Estimates," https://www.water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Agricultural-Land-And-Water-Use-Estimates (accessed April 17, 2018).

[22] See Fox Canyon Groundwater Management Agency, "Irrigation Allowance Index Information," http://www.fcgma.org/info-for-irrigation-allowance-index-training-videos/general-information (accessed January 24, 2018).

Figure 1

Strawberry Acreage in Major Strawberry-Producing Counties in California, 1984–2010



Source: Agricultural Commissioner crop reports, various counties. https://www.ventura.org/agricultural-commissioner/crop-reports/, https://countyofsb.org/agcomm/cropReportArchive.sbc, https://www.slocounty.ca.gov/Departments/Agriculture-Weights-and-Measures/All-Forms-Documents/Information/Crop-Report/Crop-Report-Archive.aspx, https://www.agdept.com/AgriculturalCommissioner/AnnualCropandLivestockReports.aspx, and https://www.co.monterey.ca.us/government/departments-a-h/agricultural-commissioner/forms-publications/crop-reports-economic-contributions#ag.

tive pesticide agent per acre of irrigated land.[23] This was 60% higher than Santa Barbara County and 160% higher than Fresno County, which has the highest total pounds of active chemical agents applied of any county in California. Pesticides used in Ventura County include known toxins and carcinogens, such as chloropicrin, Telone, and methyl bromide (California Department of Public Health 2014). Although the use of these chemicals is regulated, there have been concerns in Ventura County about the heavy use of pesticides along the agriculture-urban interface, especially near schools. According to the California Department of Public Health (2014), in 2014 Ventura County had more students attending schools within one-quarter mile of heavy pesticide application than any other county in California.

Data

The implications of our theoretical model—that adoption of a UGB should increase agricultural intensification and that the effects should be larger closer to the boundary—are tested using data on the Ventura County UGBs. We rely on land use data from the California Department of Conservation Farmland Mapping & Monitoring Program (FMMP). This program produces detailed maps and statistical data on California's agricultural resources and provides wall-to-wall coverage of Ventura and neighboring Santa Barbara Counties. Updated every two years, agricultural land is rated according to soil quality and irrigation status and then assigned to one of eight land use types (Appendix Table A1), in this way mapping contiguous areas of similar land use. Land use designations are determined using aerial imagery, public review, and field reconnaissance. For this analysis, we exclude publicly owned land,[24] and we use data from the years 1984 (14 years prior to SOAR), 1994 (4 years prior to SOAR), 2000 (immediately after SOAR), and 2010 (12 years after full implementation of growth boundaries).

The pre-UGB period is specified as 1984–1994, and the post-UGB period is defined in

[23] See California Department of Pesticide Regulation, "Pesticide Use Reporting (PUR)," http://www.cdpr.ca.gov/docs/pur/purmain.htm (accessed January 25, 2018).

[24] The FMMP data include grazing land on national forests, which cannot be intensified.

two different ways. The city of Ventura had adopted its UGB in 1995, and there was momentum among other cities to do likewise. Although other cities did not formally designate UGBs until 1998–2000, it is reasonable to think that landowners anticipated that this would happen. In any case, it was likely to have been costly for landowners to adjust immediately following the change in incentives, suggesting that intensification took place over a number of years following the adoption of UGBs. Considering these two factors, we define the post-UGB period as 1994–2010 or 2000–2010 and examine the sensitivity of our results to this specification. Although the FMMP data are available with separate observations every two years, we have chosen to only use data covering longer periods. The process of laying GIS polygons from one period on top of polygons in another period and then calculating the intersection, as described below, has the effect of cutting the polygons into smaller pieces. Repeating the process every two years during the study periods had the effect of cutting the resulting polygons into an unwieldy number of small polygons and complicating subsequent analysis.

For the purposes of this study, a polygon is considered to have intensified if it started a study period as grazing land and converted to intensive agricultural production by the end of the study period. In Ventura and Santa Barbara Counties, the primary mechanism that triggers a change from grazing to one of the other agricultural land use designations is investment in irrigation infrastructure. Thus, intensification is defined as starting with an FMMP land use designation of G and ending with L, U, S, or P (see Appendix Table A1). In our data, a negligible number of polygons change from more to less intensive uses, and so this pathway is ignored. Other land (designation X) is a catchall category for land uses not fitting into the primary classifications. It includes open space, which is undeveloped land not used for agriculture (e.g., riparian areas). Because preservation of open space was an important goal of SOAR, and because we observe some intensification of areas designated as other land, we also produce estimates using a combined grazing and other-land category. In this case, intensification is defined as a change from G or X to L, U, S, or P. The other-land category includes areas such as low-density residential development that cannot undergo agricultural intensification. Therefore, the estimated treatment effect for the grazing and other-land sample is likely to be biased toward 0.

Land use polygons are identified by overlaying GIS shape files from two different years, marking the beginning and the end of a particular period of study. Appendix Figure A2 shows an overlay of the 1994 and 2010 FMMP GIS shape files. In the first frame of this figure, the yellow polygon represents an area designated as grazing land (G) in the 1994 FMMP survey. In the second frame, the blue polygons represent areas designated as farmland of statewide importance (S) in the 2010 survey. For illustrative purposes, the location and extent of the area designated as grazing land in 1994 are also shown in the second frame of this figure, again represented as yellow. The third frame shows the intersection of the yellow and blue polygons. This intersection is identified using ArcGIS.

Following the definition of agricultural intensification described previously, there is land in Appendix Figure A2 that has undergone intensification. For this study, only the intersection of the yellow and blue areas (designated green in the figure) is counted as intensified. It is important to note that this method of identifying and counting areas of agricultural intensification likely underestimates the total area of intensification. In Appendix Figure A2, it is likely that the entire area of the blue polygon, designated S in the 2010 survey, underwent intensification following 1994. The apparent shift to the right of the 2010 polygon relative to the 1994 polygon is unlikely due to movement of the boundaries separating different land uses but, rather, to measurement error.[25] In order to take the most conservative approach to estimating the extent of agricultural intensification, we have chosen to exclude the area of the 2010 poly-

[25] Since these data are produced by a single state-level agency, we do not expect differences in measurement error between Ventura and Santa Barbara Counties. Thus, the measurement error should not be correlated with the treatment.

gon that does not intersect with the underlying 1994 polygon. Thus, the blue areas in the third frame of the figure are not counted.

The unit of analysis in this study is a GIS polygon designated by the FMMP. Individual observations are created by the intersection of polygons in two different time periods. Since the sample of observations is limited to those polygons that start a study period (either 1984–1994, 1994–2010, or 2000–2010) as grazing land (or grazing and other land), the example provided in Appendix Figure A2 results in four different polygons, representing four different observations, each with a particular area measured in square meters. The four resulting observations in this example are illustrated in Appendix Figure A3. Observations 1 and 2 are land use polygons that did not intensify, whereas observations 3 and 4 are parcels that did. Thus, in the econometric model described below, the dependent variable is a binary indicator of whether intensification has occurred. Regression estimates are adjusted to account for different sizes of polygons. Although the FMMP polygons do not correspond to tax lots or ownership units, we assume that they represent decision-making units, as in Lewis and Plantinga (2007), and we hereafter refer to them as "parcels." If this assumption does not hold, the residuals in our econometric model may be spatially correlated, an issue we address in the next section.

GIS shape files with the locations of UGBs and SOI boundaries were acquired from the Ventura County and Santa Barbara County Government GIS and mapping departments. Distance to the nearest UGB or SOI line was calculated by first identifying the centroid of each FMMP polygon and then calculating the distance to the nearest boundary.

Econometric Approach

To measure the effect of UGBs on intensification in Ventura County, we would ideally compute the difference between the average intensification rate (over a large set of agricultural parcels) in Ventura County with UGBs and the average rate in Ventura County without UGBs. As in any potential outcomes framework, this difference cannot be directly quantified because we do not simultaneously observe land parcels under both regimes. An alternative is to use the intensification rate on agricultural lands in neighboring Santa Barbara County, which did not implement UGBs, as a counterfactual. The case for causal identification is strengthened if we net out the pre-UGB difference in average intensification rates between Ventura and Santa Barbara Counties.[26]

The difference-in-differences (DID) estimator compares pretreatment and posttreatment outcomes for both treated and untreated observations. The estimated average treatment effect of growth restrictions on agricultural intensification is

$$\beta_{\text{DID}} = (\bar{Y}_{T2} - \bar{Y}_{T1}) - (\bar{Y}_{U2} - \bar{Y}_{U1}), \quad [7]$$

where $\bar{Y}$ measures the average 10-year rate of intensification for treated (T) and untreated (U) parcels during time period 1 (1984–1994) and time period 2 (1994–2010, alternatively 2000–2010). The treated observations include agricultural lands in Ventura County that are located outside the UGBs where future development is no longer an option. The untreated observations include agricultural lands located outside the SOI boundaries of cities in Santa Barbara County, where future development is still allowed. The DID estimate is robust to any time-invariant parcel-level omitted variables because the average influence of these variables drops out of the expression in equation [7].

The DID model in equation [7] is estimated using several samples. Our primary sample includes all agricultural lands in Ventura and Santa Barbara Counties that are designated in the 1984, 1994, or 2000 FMMP surveys as grazing land outside city SOI lines. The 1984 parcels are observed again in the 1994 survey, while the 1994 or 2000 parcels are observed again in the 2010 survey. This countywide sample includes 8,559 parcels for 1984–1994, 6,132 for 1994–2010, and 3,812 for 2000–2010. As in Dempsey and Plantinga (2013), a

[26] Because our outcome variable is measured as a rate of change, the pretreatment difference in intensification rates should be approximately zero if the parallel trends condition is satisfied.

second sample is restricted to only those parcels that lie within a one-mile buffer around a UGB or SOI line. The use of a one-mile buffer limits the influence of factors other than the UGB on agricultural land use decisions and allows us to test the theoretical prediction that intensification should be higher near the boundary. The one-mile sample includes 1,724, 1,142, and 745 parcels, respectively. To obtain further insights into spatially varying effects of UGBs, a third sample (2,949, 1,960, and 1,282 parcels, respectively) is constructed that includes parcels between zero and two miles from the boundary. Countywide, one-mile, and two-mile samples are also constructed for parcels that start as grazing or other land (results for these samples are reported in the Appendix).

In addition to estimating the basic DID model with different samples, we estimate a least squares regression model that recovers city-specific estimates of the average treatment effect. The model has the form

$$Y_{it} = \beta_0 + \beta_1 T + \gamma G_i + \sum_{n=1}^{N} \mu_n G_{n(i)} T + \varepsilon_{it}, \qquad [8]$$

where Y_{it} is an indicator variable[27] for whether parcel i intensified during time period t, G_i is an indicator variable for whether parcel i is in the treatment county (Ventura), N is the total number of cities in the treatment county, T is an indicator variable for time period 2, ε_{it} is a mean-zero disturbance term, and β_0, β_1, γ, and μ are parameters. The omitted category in equation [8] is agricultural parcels in Santa Barbara County. Thus, the city-specific estimates of the average treatment effects are given by μ. In all regression models, observations are weighted by the area of the parcel. When the period length is 10 years (1984–1994 or 2000–2010), the dependent variable, Y_{it}, takes the value 0 or 1. When it is 16 years (1994–2010), we normalize Y_{it} for a 10-year period, and it takes the values 0 or 0.625.

The unit of observation in the above models (parcels) may not correspond to the decision-making unit for agricultural landowners. This mismatch between observational and decision-making units could induce spatial correlation in the error terms. To address this, we estimate equation [8] with cluster-robust standard errors where clusters are defined in terms of contiguous areas enclosed by UGBs or SOI lines.[28] There is also potential for spatial interaction among landowners' units due to peer and network effects (e.g., lower intensification costs if one's neighbor has intensified). We do not treat spatial interaction explicitly because doing so requires knowledge of the unobserved structure of interactions.[29] In Ventura County, the three cities of Fillmore, Santa Paula, and Oxnard each have discrete UGBs, whereas the UGBs in Camarillo, Thousand Oaks, and Moorpark enclose a contiguous area. Thus, there are four clusters in Ventura County: Fillmore, Santa Paula, Oxnard, and Camarillo/Thousand Oaks/Moorpark. In Santa Barbara County, only Goleta and Santa Barbara have contiguous SOIs. Thus, there are six clusters defined for Santa Barbara County: Carpinteria, Santa Barbara/Goleta, Lompoc, Solvang, Santa Maria, and Guadalupe. As a robustness check, we also define separate clusters for each city; the results are essentially unchanged (Appendix Table A4).

Identification

There are three key identifying assumptions needed for our application of the DID estimator. The first is that agricultural parcels in Santa Barbara County provide a valid counterfactual for parcels in Ventura County. Namely, had UGBs not been implemented in Ventura, rates of intensification during the post-UGB period would have been similar in Ventura County to what they were in Santa Barbara County. Although we cannot test this assumption directly, we can compare intensi-

[27] Unless the period length is 16 years, as explained below.

[28] Rather than choose critical values from the standard normal distribution, we follow Cameron and Miller (2015) and use critical values from the student-t distribution with $C - 1$ df, where C is the number of clusters.

[29] Delgado and Florax (2015) provide the DID estimator for the case of spatial interactions among observational units. The estimator requires specification of the "W matrix" as in conventional models with spatially correlated residuals. Simulations in Delgado and Florax (2015) show that incorrectly modeling spatial correlation as spatial interaction severely biases treatment effect estimates.

fication rates during the 1984–1994 period in the two counties. As shown in Table 1, intensification rates during the pretreatment period were similar in Ventura and Santa Barbara. Countywide, the 10-year intensification rate on grazing land was 8% in Ventura and 7% in Santa Barbara. In the one-mile buffer, the intensification rates were 11% and 12%, and in the two-mile buffer, rates were 10% and 15%, respectively.[30] Formal tests of parallel trends, presented in the next section, confirm these results.[31]

There are a number of additional reasons why Santa Barbara County should be a valid counterfactual for Ventura County. As discussed above, land use and agricultural production, in particular, are similar in the two counties. Agricultural producers supply to the same national and global output markets and access the same input markets for equipment, seasonal labor, and so on. During the study period, population, jobs, and labor force growth as well as net domestic migration were similar in the two counties.[32] Given the evidence for parallel trends, differences between the counties would have had to emerge during the posttreatment period in order to invalidate our research design. As discussed above, access to groundwater and expansion in wine production could have differentially affected intensification rates after the adoption of UGBs. However, these factors would have tended to reduce intensification in Ventura County relative to Santa Barbara, thereby attenuating the estimated effects of the UGBs.

The second identifying assumption is that the UGB policy in Ventura County did not affect intensification rates in Santa Barbara County (i.e., noninterference). The UGB policy affected the supply of agricultural commodities and land for housing development in Ventura County, which could have had spillover effects on markets in Santa Barbara County. This is unlikely in the case of agricultural production, as producers in both counties supply to national and global commodity markets. As such, the factors influencing agricultural land use decisions, such as output and input prices, are exogenous to decisions made within the two counties. More plausibly, the restriction on housing development in Ventura County could have increased housing prices and the quantity of land supplied for housing development in Santa Barbara County. If this raised development rents in Santa Barbara County, there would be less of an incentive for agricultural intensification, according to our theory. However, time series of housing price indices do not show evidence of spillover effects (Figure 2). Rates of price growth in the two counties are highly correlated.[33] Prices in Santa Barbara County grew at a somewhat higher rate between 2000 and 2008; however, this pattern is contrary to what would be expected in the presence of spillovers. The UGBs made the supply of land for housing more inelastic in Ventura County, which means that

Table 1

Ten-Year Intensification Rates on Grazing Land by County, Period, and Starting Land Use

Time Period	Countywide	0–1 Mile	0–2 Miles
Santa Barbara County			
1984–1994	0.067	0.115	0.152
1994–2010	0.086	0.122	0.155
2000–2010	0.065	0.102	0.130
Ventura County			
1984–1994	0.075	0.114	0.099
1994–2010	0.253	0.330	0.301
2000–2010	0.174	0.304	0.259
Estimated average treatment effect (1994–2010)	0.159	0.209	0.199
Estimated average treatment effect (2000–2010)	0.101	0.203	0.182

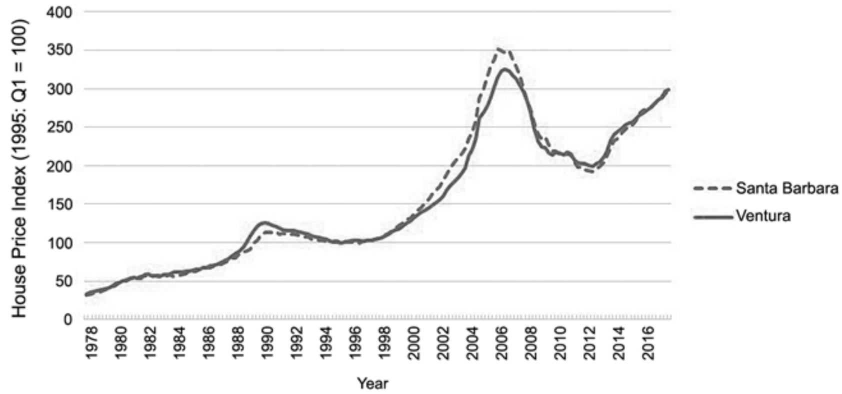
[30] For the grazing and other-land samples, pre-UGB intensification rates are also similar in the two counties; see Appendix Table A2.

[31] When parallel trends is not satisfied, a counterfactual can be constructed using synthetic control methods. We do not pursue this approach because we find evidence that supports parallel trends.

[32] Over the period 1984–2010, the average annual population growth rate was 1.4% in Ventura County and 1.0% in Santa Barbara County. The average annual jobs growth rate was 1.2% in both counties. Over the period 1991–2010, the labor force growth rate was 0.8% in Ventura County and 0.5% in Santa Barbara County, and the average net domestic migration was –2,936 and –2,244 persons, respectively.

[33] The housing price index in Figure 2 is a repeat-sales index that represents the housing price level relative to a 1995 base year.

Figure 2
All-Transactions House Price Index for Ventura and Santa Barbara Counties



Source: Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/ATNHPIUS42200Q (accessed January 23, 2018).

prices should have risen more rapidly there than in Santa Barbara County.

The final identifying assumption is that the placement of UGBs is exogeneous. In particular, we require that the location of UGBs is uncorrelated with unobserved factors that influence intensification. As discussed above, the placement of the Ventura UGBs was based on observed characteristics, namely, the SOI lines. Because we observe the SOI lines for untreated parcels in Santa Barbara County, we are able to control for any factors that influenced the location of the SOI lines, including potential unobserved determinants of intensification. The key assumption is that the SOI lines in the two counties were designated in a similar way with respect to the likelihood of intensification. This assumption seems reasonable given that the designation of SOI boundaries is required under state law and is done to satisfy a common set of objectives with regard to urban development and agricultural land preservation.

5. Results

Average Treatment Effect Estimates

Prior to the adoption of UGBs in Ventura County, intensification rates were similar in Ventura and Santa Barbara Counties (Table 1). Over the period 1994–2010, intensification rates increased in both counties, but the changes were more dramatic in Ventura County. Countywide, the 10-year intensification rate increased by 17.8 percentage points (from 7.5% to 25.3%) in Ventura County and by only 1.9 percentage points in Santa Barbara County. Thus, we estimate that the average effect of the UGBs in Ventura County was to increase the intensification rate by 15.9 percentage points on a countywide basis. This result is in line with our first theoretical prediction that elimination of future development options should increase agricultural intensification. The effect is more pronounced in the one-mile buffer just outside the UGBs. Here we find an increase in the 10-year intensification rate of 21.6 percentage points in Ventura County and a small (0.7 percentage point) increase in Santa Barbara County. This yields an average treatment effect of 20.9 percentage points. For the two-mile buffer, we find an average treatment effect of 19.9 percentage points. These findings are in agreement with our second theoretical prediction that changes in intensification should be largest in areas just outside the UGB.[34]

The estimate of the countywide average treatment effect is lower by 5.8 percentage points (15.9 – 10.1) for the 2000–2010 period (Table 1). This difference suggests that inten-

[34] We measure intensification over time periods of 10 and 16 years, and it is possible that the adjustment to the UGB policy continues beyond the study period.

Table 2

Least Squares Regression Results for Grazing Land by Buffer Width and Time Period, with Cluster-Robust Standard Errors

Variable	Estimate	Std. Error	*p*-Value	Estimate	Std. Error	*p*-Value
	1994–2010			2000–2010		
	Countywide					
Intercept	0.067*	0.021	0.02	0.067*	0.021	0.02
Ventura	0.008	0.031	0.80	0.008	0.031	0.80
Post-UGB	0.019	0.020	0.39	–0.002	0.011	0.85
Ventura × Post	0.159*	0.061	0.04	0.101	0.050	0.08
Observations		14,691			12,371	
R-squared		0.03			0.01	
	0–1 Mile					
Intercept	0.115*	0.042	0.03	0.115*	0.042	0.03
Ventura	–0.001	0.085	0.99	–0.001	0.085	0.99
Post-UGB	0.007	0.020	0.73	–0.013	0.025	0.62
Ventura × Post	0.209**	0.040	<0.005	0.203*	0.067	0.02
Observations		2,866			2,469	
R-squared		0.05			0.01	
	0–2 Miles					
Intercept	0.152**	0.046	0.01	0.152**	0.046	0.01
Ventura	–0.053	0.067	0.46	–0.053	0.067	0.46
Post-UGB	0.003	0.012	0.82	–0.022*	0.007	0.02
Ventura × Post	0.199**	0.041	<0.005	0.182*	0.061	0.02
Observations		4,909			4,231	
R-squared		0.04			0.02	

Note: Critical values are from Student's *t*-distribution with 9 df (see n. 28). The 1994–2010 estimates are normalized for a 10-year period (see text).
*, ** significance at the 5% and 1% levels, respectively.

sification occurred prior to the actual implementation of the UGBs. Using the total area of grazing land in Ventura County at the start of the two periods,[35] we calculate that 1,733 acres of land intensified over the 1994–2000 period as a result of the UGBs compared to 1,419 acres over the period 2000–2010. Of the land that intensified over the period 1994–2000, approximately 47% of it was located within two miles of UGBs.[36] By the 2000–2010 period, only 25% of the land that intensified was within two miles of UGBs. Thus, our results indicate that a large amount of the early intensification occurred in close proximity to UGBs and that later intensification tended to happen farther away.

Results for the grazing and other-land sample are qualitatively similar (Appendix Table A2). The average treatment effect estimates are positive and largest in the buffers closest to the UGBs. However, the effects are about one-half as large when we include other land in the sample. This is likely because intensification may be infeasible on some lands classified as other, such as low-density rural development.

Regression results for a simplified version of the model in equation [8], which estimates a single treatment effect for Ventura County, are found in Table 2. The first set of columns (1–3) report results for the 1994–2010 sample; the second set (columns 4–6) report results for the 2000–2010 period. In each case, three versions of the model—countywide, zero-to-one-mile buffer, and zero-to-two-mile

[35] The totals were 19,704 acres in 1994 and 14,193 acres in 2000. To put the acreage changes in perspective, the U.S. Census of Agriculture reports that the median farm size in Ventura County in 1997 was 19 acres.

[36] There were 6,421 acres of grazing land in Ventura County within two miles of UGBs in 1994 and 4,478 acres in 2000.

buffer—are presented. The coefficient on the county variable measures the pretreatment difference in intensification rates. The estimate is not statistically significant in all cases, providing support for the parallel trends assumption.[37] Point estimates of the average treatment effect are given by the coefficients on the county and time interaction terms.[38] The estimates are significantly different from 0 in five of the six models, the exception being the countywide model for 2000–2010. Results for the grazing and other-land sample reveal significant average treatment effects but only for the 1994–2010 period (Table A3).

Regression results for the fully specified version of equation [8] with city-time interaction terms are presented in Table 3. Using the zero-to-one-mile samples, estimates are produced for Thousand Oaks, Moorpark, Santa Paula, and Fillmore but not for Camarillo and Oxnard because of the lack of grazing land outside these cities. The results for 1994–2010 show similar average treatment effects outside Moorpark and Santa Paula (0.295 and 0.367 and significant at the 1% level), but not statistically significant effects for Thousand Oaks and Fillmore. For the 2000–2010 period, only the estimate for Santa Paula is significantly different from 0. This suggests that for Moorpark, most of the intensification occurred prior to 2000, but for Santa Paula, the intensification continued after 2000.

Table 3

City-Specific Least Squares Estimates of the Average Treatment Effect for Grazing Land in the One-Mile Buffer, with Cluster-Robust Standard Errors

Variable	Estimate	Std. Error	*p*-Value
	1994–2010		
Intercept	0.115*	0.047	0.02
Post-UGB	0.006	0.071	0.94
Ventura	–0.004	0.049	0.94
City-by-Period Indicators			
Thousand Oaks × Post	0.108	0.093	0.25
Moorpark × Post	0.295**	0.101	<0.005
Santa Paula × Post	0.367**	0.081	<0.005
Fillmore × Post	0.210	0.168	0.21
Observations		2,866	
R-squared		0.07	
	2000–2010		
Intercept	0.115*	0.048	0.02
Post-UGB	–0.013	0.074	0.86
Ventura	–0.001	0.051	0.98
City-by-Period Indicators			
Thousand Oaks × Post	–0.008	0.114	0.94
Moorpark × Post	0.222	0.167	0.19
Santa Paula × Post	0.544**	0.128	<0.005
Fillmore × Post	0.316	0.253	0.21
Observations		2,469	
R-squared		0.06	

Note: Critical values are from Student's t-distribution with 9 df (see n. 28). The 1994–2010 estimates are normalized for a 10-year period (see text).

*, ** significance at the 5% and 1% levels, respectively.

Additional Evidence

We contend that the increase in agricultural intensification in Ventura County resulted from the elimination of development opportunities on lands outside UGBs. If this is the case, there should be a discontinuous increase in land prices moving from outside to inside the boundaries. First, the elimination of the development option (weakly) lowers the land price in equation [1]. If a profit-maximizing landowner would develop at a finite time t^*, it must be because this increases the land price and, conversely, that a prohibition on development lowers the price. Second, in standard urban spatial models, development restrictions increase land prices within the city by making developable land scarcer (e.g., Plantinga [2007]). This implies a price discontinuity in Ventura County as the result of relatively scarce developable land inside the UGBs and the absence of development opportunities outside the UGBs. In contrast, we should not observe a jump in prices moving across the SOI lines in Santa Barbara County because development is permitted on both sides of these boundaries.

As a test of these hypotheses, we estimate a regression discontinuity model of land values in Ventura and Santa Barbara Counties. The key assumption of the model is that, with the exception of development restrictions, all other determinants of land value vary continuously across the boundary. For example, as

[37] Although we find similar 10-year intensification rates in the pretreatment period, we cannot rule out the possibility that the rates differed over shorter time spans.

[38] The estimates are identical to those reported in Table 1.

Table 4
Discontinuous Changes in Land Values at UGBs and SOI Lines in Ventura and Santa Barbara Counties

Variable	Parameter Estimate	Std. Error	p-Value	Parameter Estimate	Std. Error	p-Value
	Ventura County			Santa Barbara County		
Intercept	295,501***	31,407.3	0.000	35,590	30,612.7	0.245
Distance	–149***	22.0	0.000	110	66.1	0.097*
Inside	193,504***	48,429.1	0.000	34,655	32,664.4	0.289
Distance × Inside	21	29.2	0.472	–139**	68.8	0.044
Observations		8,476			12,681	
R-squared		0.053			0.002	

*, **, *** significance at the 10%, 5%, and 1% levels, respectively.

discussed in Section 3, urban spatial theory predicts declining development rents with distance to an urban center. However, because proximity to the urban center varies continuously across the UGBs or SOI lines, the declining urban-rent gradient does not affect the model's estimates. We produce these estimates using proprietary data from DataQuick for the year 2012. The dataset includes descriptive variables for all parcels in Ventura and Santa Barbara Counties identified by the Assessor Parcel Number (APN). The variables of interest are the Assessor Parcel Number; the market value of the land, as determined by the assessor; and the lot size expressed in square feet. The latter two variables are combined to calculate a value per acre for each Assessor Parcel Number under consideration. The estimated land value per acre does not include the value of improvements on the property, such as houses.[39]

We select a sample of parcels that fall within one-eighth-mile buffers on both sides of UGBs in Ventura County and SOI lines in Santa Barbara County. For each county, we estimate the following local linear regression model, as in Grout, Jaeger, and Plantinga (2011):

$$LV_i = \alpha_0 + \alpha_1 Dist_i + \alpha_2 IN_i + \alpha_3 Dist_i \cdot IN_i + \varepsilon_i, \quad [9]$$

where LV_i is the land value per acre for parcel i, $Dist_i$ is the linear distance from parcel i to the boundary, IN_i is an indicator variable that takes the value 1 if parcel i is inside the boundary, ε_i is a random disturbance term, and αs are the parameters. Results are presented in Table 4. The coefficient of interest is α_2, which indicates the discontinuous change in land value at the boundary. Consistent with the proposed mechanism, land values jump by almost $200,000 per acre inside of UGBs in Ventura County, whereas in Santa Barbara County the change in land value is not significantly different from 0.

6. Conclusions

Environmental policies can induce market adjustments that result in suboptimal levels of the targeted (and other) externalities. While these outcomes are often referred to as "unintended consequences," it is difficult to know the motives of policy makers or what they understand about the effects of policies. Nevertheless, it is important to understand the mechanisms that can lead to additional effects of environmental policies. In this study, we show how a policy that eliminates choices along a particular intended margin creates incentives for adjustments along unintended margins. In addition to yielding an outcome seemingly at odds with the policy goal, the policy can exacerbate existing externality problems. In general, one needs a system of incentives to correct decisions on all relevant margins (Goulder and Parry 2008), an approach that is likely to face many challenges in practice.

We find that the UGBs in Ventura County increased intensification rates by a sizable amount (16 percentage points) on a countywide basis, and they had an even larger effect

[39] We do not use the market value of improvements as determined by the assessor, an additional variable provided by DataQuick.

(18 to 21 percentage points) in the areas just adjacent to cities. As discussed, agricultural intensification in Ventura County—particularly, increases in strawberry production—leads to increases in groundwater pumping and applications of pesticides and fertilizers. The fact that intensification rates are highest just outside UGBs suggests that human exposure to agricultural chemicals increased as a result of the growth controls. This is consistent with the California Department of Public Health finding that Ventura County has the highest student population attending schools close to heavy pesticide application (California Department of Public Health 2014). Given the increasing adoption of urban containment policies in the United States (Wassmer 2006), and the fact that these policies are often motivated by agricultural land preservation, there is potential for similar effects in other regions.

There is a large body of literature measuring the amenity value of farmland using revealed and stated preference methods. A review by Bergstrom and Ready (2009) offers two important findings for our study. First, households tend to have a preference for low-intensity agriculture, and many even regard high-intensity agriculture as a disamenity. Second, although studies find a mix of results, there is some evidence that residential locations close to farmland are preferred.[40] Thus, by encouraging agricultural intensification near cities, SOAR may have failed to produce substantial amenity benefits for the citizens of Ventura County.

An extension of this research is to explore further the use of data on water use and fertilizer and pesticide applications. Rather than measure effects of UGBs on agricultural land use decisions, it would be ideal to measure direct effects on environmental outcomes. Although we document the changes in water, fertilizer, and pesticide use that are likely associated with land use changes in Ventura County, estimates of the effects of UGBs on groundwater pumping, chemical use, and other potential externalities would be useful to obtain.

[40]The mixed results on proximity may be because farmland can be both an amenity and a disamenity (Bergstrom and Ready 2009).

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References

Alix-Garcia, J. M., E. N. Shapiro, and K. R. Sims. 2012. “Forest Conservation and Slippage: Evidence from Mexico’s National Payments for Ecosystem Services Program.” *Land Economics* 88 (4): 613–38.

Ayres, A. B., E. C. Edwards, and G. D. Libecap. 2018. “How Transaction Costs Obstruct Collective Action: The Case of California’s Groundwater.” *Journal of Environmental Economics and Management* 91: 46-65.

Bergstrom, J. C., and R. C. Ready. 2009. “What Have We Learned from over 20 Years of Farmland Amenity Valuation Research in North America?” *Review of Agricultural Economics* 31: 21–49.

Bigelow, D. P., and A. J. Plantinga. 2017. “Town Mouse and Country Mouse: Effects of Urban Growth Controls on Equilibrium Sorting and Land Prices.” *Regional Science and Urban Economics* 65: 104–15.

California Department of Public Health. 2014. *Agricultural Pesticide Use Near Public Schools in California*. Sacramento: California Department of Public Health, California Environmental Health Tracking Program.

Cameron, A. C., and D. L. Miller. 2015. “A Practitioner’s Guide to Cluster-Robust Inference.” *Journal of Human Resources* 50: 317–72.

Capozza, D. R., and R. W. Helsley. 1990. “The Stochastic City.” *Journal of Urban Economics* 28: 187–203.

Capozza, D. R., and Y. Li. 1994. “The Intensity and Timing of Investment: The Case of Land.” *The American Economic Review* 84 (4): 889–904.

———. 2002. “Optimal Land Development Decisions.” *Journal of Urban Economics* 51: 123–42.

CDPR (California Department of Pesticide Regulation). 2015. *California Pesticide Information Portal*. Sacramento, CA: CDPR. Available at http://calpip.cdpr.ca.gov/main.cfm.

Cho, S.-H., Z. Chen, and S. T. Yen. 2008. "Urban Growth Boundary and Housing Prices: The Case of Knox County, Tennessee." *Review of Regional Studies* 38: 29–44.

Cho, S.-H., Z. Chen, S. T. Yen, and D. B. Eastwood. 2006. "Estimating Effects of an Urban Growth Boundary on Land Development." *Journal of Agricultural and Applied Economics* 38: 287–98.

Cho, S.-H., O. A. Omitaomu, N. C. Poudyal, and D. B. Eastwood. 2007. "The Impact of an Urban Growth Boundary on Land Development in Knox County, Tennessee: A Comparison of Two-Stage Probit Least Squares and Multilayer Neural Network Models." *Journal of Agricultural and Applied Economics* 39: 701–17.

Claassen, R., L. Hansen, M. Peters, V. Breneman, M. Weinberg, A. Cattaneo, P. Feather, et al. 2001. *Agri-Environmental Policy at the Crossroads: Guideposts on a Changing Landscape*. Agricultural Economic Report 794. Washington, DC: U.S. Department of Agriculture.

Cunningham, C. R. 2007. "Growth Controls, Real Options, and Land Development." *Review of Economics and Statistics* 89: 343–58.

Delgado, M. S., and R. J. Florax. 2015. "Difference-in-Differences Techniques for Spatial Data: Local Autocorrelation and Spatial Interaction." *Economics Letters* 137: 123–26.

Dempsey, J. A., and A. J. Plantinga. 2013. "How Well Do Urban Growth Boundaries Contain Development? Results for Oregon Using a Difference-In-Difference Estimator." *Regional Science and Urban Economics* 43: 996–1007.

Dixit, A. 1989. "Entry and Exit Decisions under Uncertainty." *Journal of Political Economy* 97: 620–38.

FCGMA (Fox Canyon Groundwater Management Agency). 2015. *Crop Year 2014/15 Reported Extractions*. Ventura, CA: FCGMA. Available at http://fcgma.org.

Fulton, W., M. Nguyen, C. Williamson, P. Shigley, E. Kancler, J. Dietenhofer, and J. Sourial. 2002. "Growth Management Ballot Measures in California." Ventura, CA: Solimar Research Group. Available at https://www.researchgate.net/publication/253659410_Growth_Management_Ballot_Measures_in_California.

Gillingham, K., M. J. Kotchen, D. S. Rapson, and G. Wagner. 2013. "Energy Policy: The Rebound Effect is Overplayed." *Nature* 493: 475–76.

Goulder, L. H., and L. W. Parry. 2008. "Instrument Choice in Environmental Policy." *Review of Environmental Economics and Policy* 2: 152–74.

Grout, C. A., W. K. Jaeger, and A. J. Plantinga. 2011. "Land-Use Regulations and Property Values in Portland, Oregon: A Regression Discontinuity Design Approach." *Regional Science and Urban Economics* 41: 98–107.

Jackson, K. 2016. "Do Land Use Regulations Stifle Residential Development? Evidence from California Cities." *Journal of Urban Economics* 91: 45–56.

Jiang, L., X. Deng, and K. C. Seto. 2013. "The Impact of Urban Expansion on Agricultural Land Use Intensity in China." *Land Use Policy* 35: 33–39.

Jun, M.-J. 2004. "The Effects of Portland's Urban Growth Boundary on Urban Development Patterns and Commuting." *Urban Studies* 41: 1333–48.

Kline, J. D., and R. J. Alig. 1999. "Does Land Use Planning Slow the Conversion of Forest and Farmlands?" *Growth and Change* 30: 3–22.

Knaap, G. J. 1985. "The Price Effects of Urban Growth Boundaries in Metropolitan Portland, Oregon." *Land Economics* 61: 26–35.

Lewis, D. J., and A. J. Plantinga. 2007. "Policies for Habitat Fragmentation: Combining Econometrics with GIS-based Landscape Simulations." *Land Economics* 83 (2): 109–27.

Lockeretz, W. 1988. "Urban Influences on the Amount and Structure of Agriculture in the North-Eastern United States." *Landscape and Urban Planning* 16: 229–44.

Lopez, R. A., A. O. Adelaja, and M. S. Andrews. 1988. "The Effects of Suburbanization on Agriculture." *American Journal of Agricultural Economics* 70: 346–58.

Matson, P. A., W. J. Parton, A. Power, and M. Swift. 1997. "Agricultural Intensification and Ecosystem Properties." *Science* 277: 504–9.

Newburn, D. A., and P. Berck. 2006. "Modeling Suburban and Rural-Residential Development beyond the Urban Fringe." *Land Economics* 82 (4): 481–99.

———. 2011. "Growth Management Policies for Exurban and Suburban Development: Theory and an Application to Sonoma County, California." *Agricultural and Resource Economics Review* 40: 375–92.

Pendall, R. 1999. "Do Land-Use Controls Cause Sprawl?" *Environment and Planning B: Planning and Design* 26: 555–71.

———. 2000. "Local Land Use Regulation and the Chain of Exclusion." *Journal of the American Planning Association* 66: 125–42.

Phillips, J., and E. Goodstein. 2000. "Growth Management and Housing Prices: The Case of Portland, Oregon." *Contemporary Economic Policy* 18: 334–44.

Plantinga, A. J. 2007. "The Economics of Conservation Easements." In *Land Policies and Their Outcomes: Proceedings of the 2006 Land Policy Conference*, edited by G. K. Ingram and Y.-H. Hong. Cambridge, MA: Lincoln Institute of Land Policy.

Quigley, J. M., and L. A. Rosenthal. 2005. "The Effects of Land Use Regulation on the Price of Housing: What Do We Know? What Can We Learn?" *Cityscape* 2005: 69–137.

Searchinger, T., R. Heimlich, R. A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T.-H. Yu. 2008. "Use of US Croplands for Biofuels Increases Greenhouse Gases through Emissions from Land-Use Change." *Science* 319: 1238–40.

Severen, C., and A. J. Plantinga. 2018. "Land-Use Regulations, Property Values, and Rents: Decomposing the Effects of the California Coastal Act." *Journal of Urban Economics* 107: 65–78.

Sohngen, B., R. Mendelsohn, and R. Sedjo. 1999. "Forest Management, Conservation, and Global Timber Markets." *American Journal of Agricultural Economics* 81: 1–13.

Solow, R. M. 1973. "On Equilibrium Models of Urban Location." In *Essays in Modern Economics*, edited by J. M. Parkin, 2–16. London: Longman.

Stavins, R. N., and A. B. Jaffe. 1990. "Unintended Impacts of Public Investments on Private Decisions: The Depletion of Forested Wetlands." *American Economic Review* 1990: 337–52.

Tilman, D., K. G. Cassman, P. A. Matson, R. Naylor, and S. Polasky. 2002. "Agricultural Sustainability and Intensive Production Practices." *Nature* 418: 671.

Wassmer, R. W. 2006. "The Influence of Local Urban Containment Policies and Statewide Growth Management on the Size of United States Urban Areas." *Journal of Regional Science* 46: 25–65.

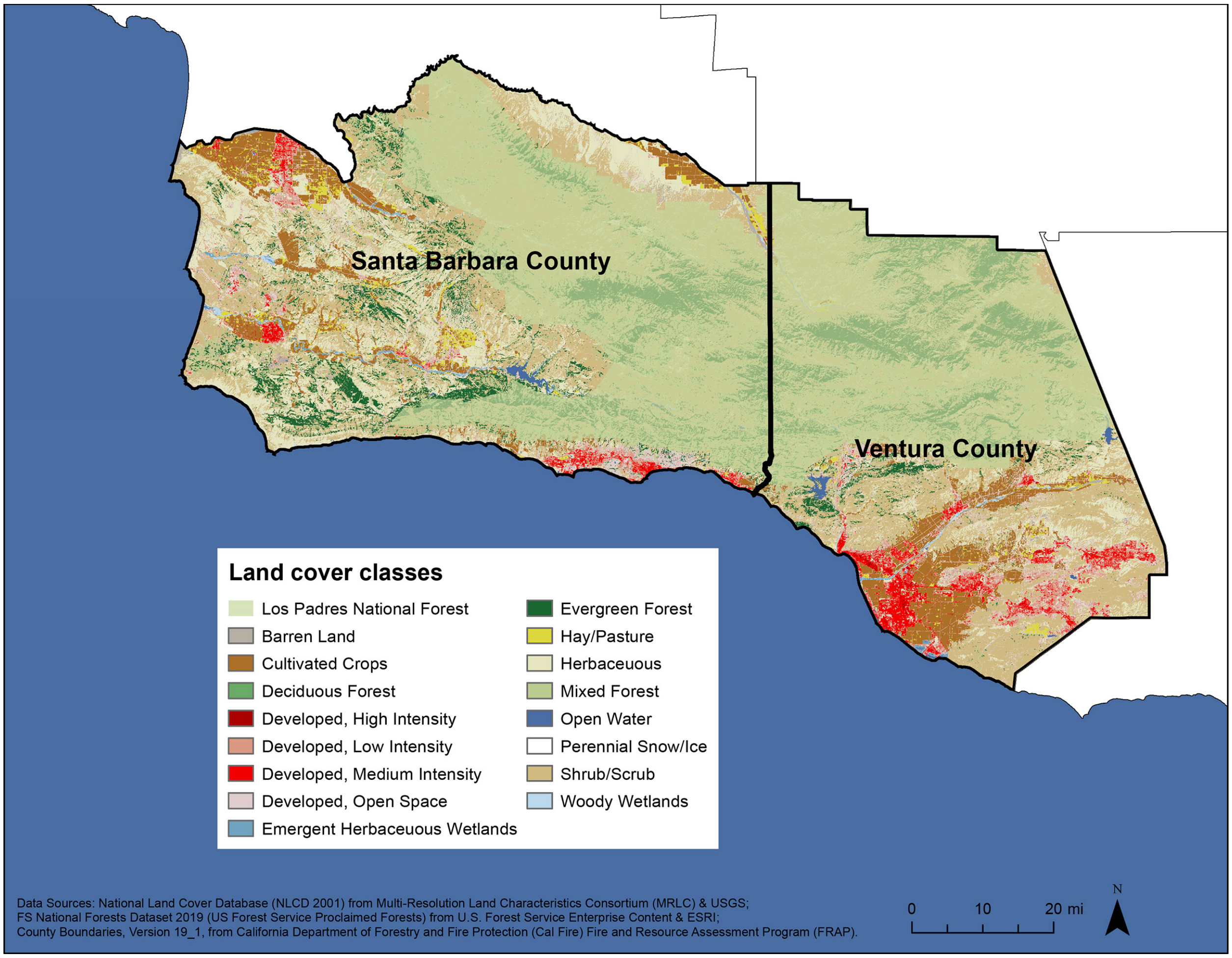
Wu, J. 2000. "Slippage Effects of the Conservation Reserve Program." *American Journal of Agricultural Economics* 82: 979–92.

Wu, J., M. Fisher, and U. Pascual. 2011. "Urbanization and the Viability of Local Agricultural Economies." *Land Economics* 87 (1): 109–25.

Wu, J., and A. J. Plantinga. 2003. "The Influence of Public Open Space on Urban Spatial Structure." *Journal of Environmental Economics and Management* 46: 288–309.

Appendix

Figure A1: Land cover in Ventura and Santa Barbara Counties in 2001.



Source: National Land Cover Database 2001. https://www.mrlc.gov/data/nlcd-2001-land-cover-conus, accessed 9-18-19.

Figure A2: Farmland Mapping & Monitoring Program 1994 and 2010 GIS shape files

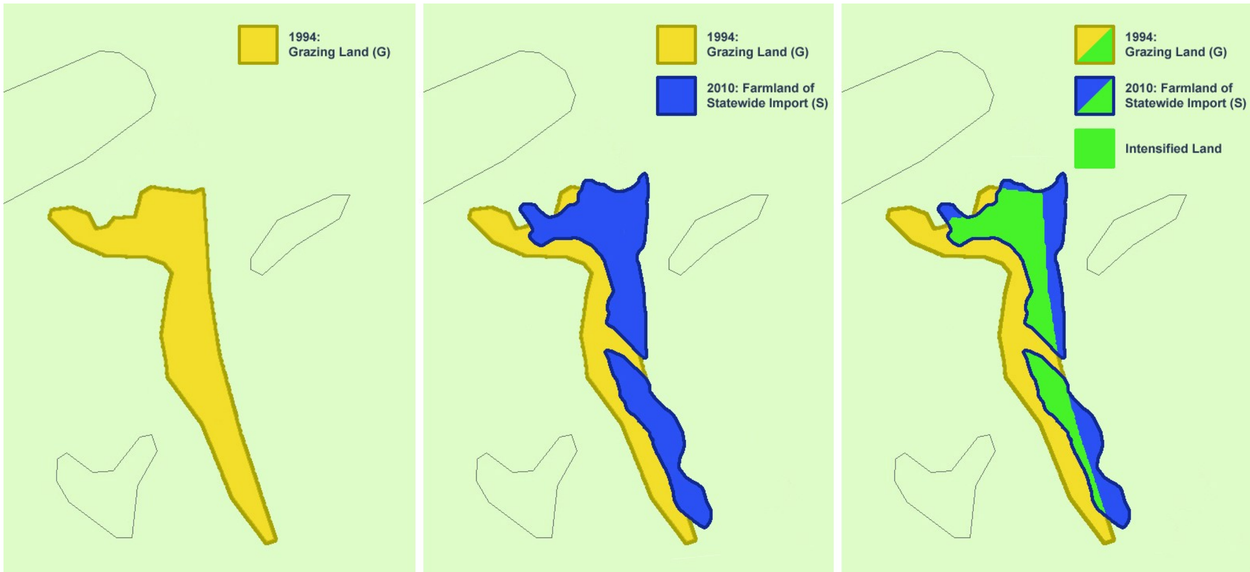


Figure A3: The intersection of the 1994 and 2010 GIS shape files result in four different polygons for analysis

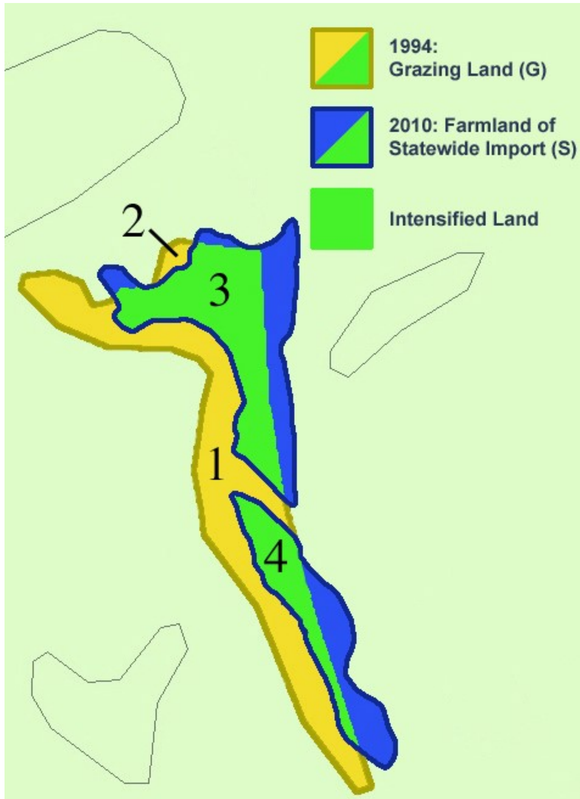


Figure A4: Urban Growth Boundaries and Sphere of Influence Lines in Ventura and Santa Barbara Counties

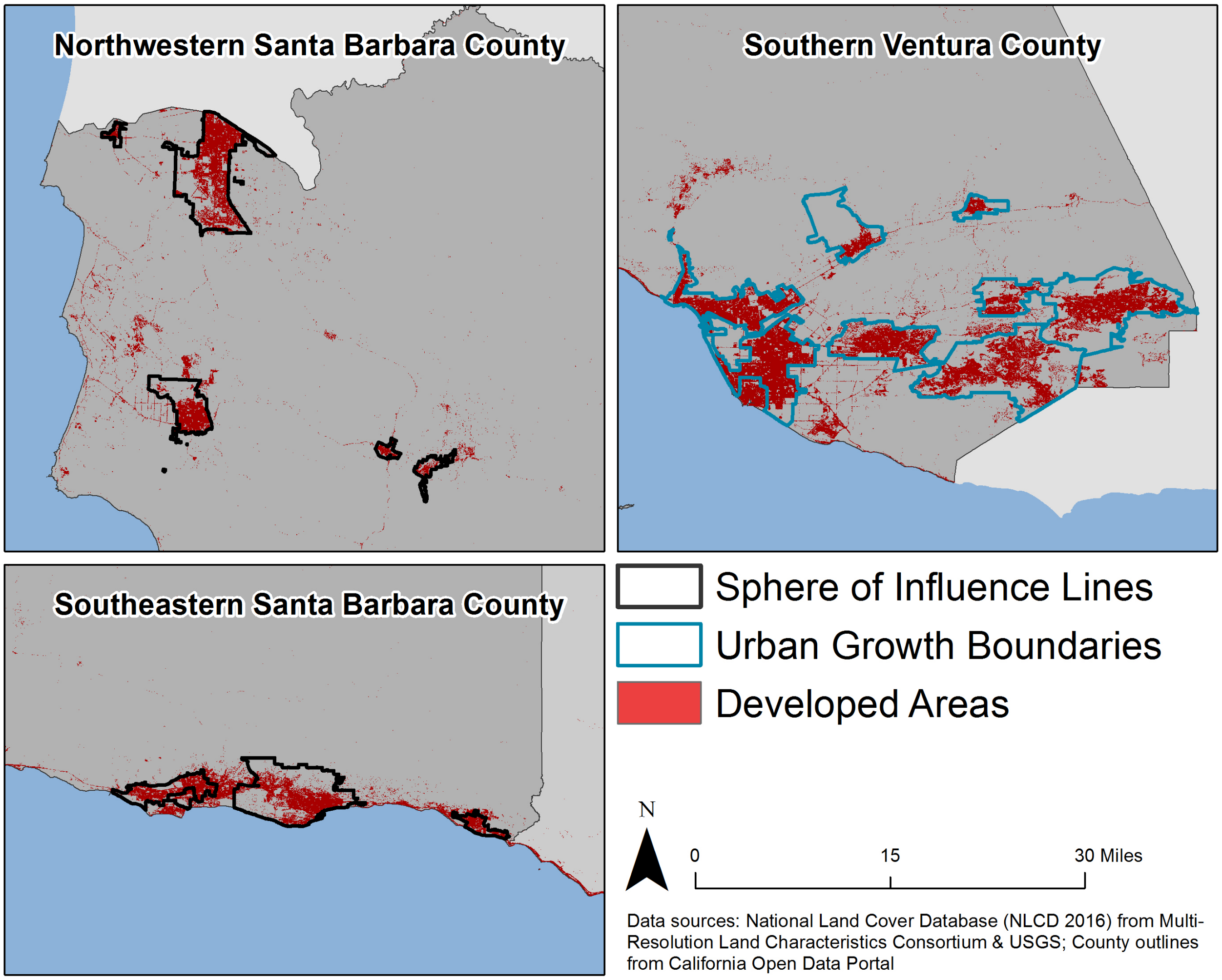


Table A1: California Department of Conservation - Farmland Mapping & Monitoring Program

Designation	**Description**
Prime Farmland (P)	Farmland with the best combination of features able to sustain long term agricultural production. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Land must have been used for irrigated agricultural production at some time during the four years prior to the mapping.
Farmland of Statewide Importance (S)	Farmland similar to Prime Farmland but with minor shortcomings, such as greater slopes or less ability to store soil moisture. Land must have been used for irrigated production at some time during the four years prior to the mapping date.
Unique Farmland (U)	Farmland of lesser quality soils used for the production of the state's leading agricultural crops. This land is usually irrigated. Land must have been cropped at some time during the four years prior to the mapping date.
Farmland of Local Importance (L)	Land of importance to the local agricultural economy as determined by each county's board of supervisors and a local advisory committee. This land is usually irrigated.
Grazing Land (G)	Land on which existing vegetation is suited to the grazing of livestock.
Urban Land (D)	Land occupied by structures with a building density of at least 1 unit to 1.5 acres, or approximately 6 structures to a 10-acre parcel. This land is used for residential, industrial, commercial, construction, institutional, public administration, railroad and other transportation yards, airports, golf courses, sanitary landfills, sewage treatment, water control structures, and other developed purposes.
Other Land (X)	Land not included in any other mapping category. Common examples include low density rural developments; brush, timber, wetland, and riparian areas not suitable for livestock grazing; strip mines, borrow pits; and water bodies smaller than 40 acres. Vacant and nonagricultural land surrounded on all sides by urban development and greater than 40 acres is mapped as Other Land.
Water (W)	Perennial water bodies with an extent of at least 40 acres.

Table A2: Ten-year Intensification Rates On Grazing and Other Land by County, Period, and Starting Land Use

	Intensification rates		
Time period	**County-wide**	**0 - 1 miles**	**0-2 miles**
Santa Barbara County			
1984-1994	0.06	0.10	0.12
1994-2010	0.07	0.09	0.11
2000-2010	0.01	0.02	0.02
Ventura County			
1984-1994	0.06	0.11	0.08
1994-2010	0.14	0.21	0.17
2000-2010	0.05	0.14	0.08
Estimated Avg. Treatment Effect (1994-2010)	**0.07**	**0.11**	**0.10**
Estimated Avg. Treatment Effect (2000-2010)	**0.04**	**0.11**	**0.10**

Table A3: Regression Results for Grazing and Other Land by Buffer Width and Time Period, with Cluster-Robust Standard Errors

Variable	Estimate	Std. Error	p-value	Estimate	Std. Error	p-value
		1994-2010			2000-2010	
			Countywide			
Intercept	0.057**	0.017	0.01	0.057**	0.017	0.01
Ventura	0.002	0.022	0.92	0.002	0.022	0.92
Post-UGB	0.010	0.013	0.48	-0.052*	0.017	0.02
Ventura×Post	0.072*	0.023	0.02	0.042	0.020	0.08
No. Obs.		20,451			16,585	
R-squared		0.01			0.02	
			0-1 miles			
Intercept	0.096*	0.036	0.03	0.096*	0.036	0.03
Ventura	0.010	0.050	0.85	0.010	0.050	0.85
Post-UGB	-0.008	0.023	0.73	-0.078*	0.031	0.04
Ventura×Post	0.110*	0.046	0.05	0.108	0.075	0.19
No. Obs.		4,757			3,935	
R-squared		0.02			0.03	
			0-2 miles			
Intercept	0.122*	0.041	0.02	0.122*	0.041	0.02
Ventura	-0.043	0.043	0.35	-0.043	0.043	0.35
Post-UGB	-0.009	0.016	0.57	-0.100*	0.016	0.02
Ventura×Post	0.098*	0.034	0.02	0.103	0.045	0.06
No. Obs.		7,868			6,489	
R-squared		0.01			0.02	

** indicates significance at the 1% level; * indicates 5% level.
Notes: Critical values are from the student-t distribution with 9 degrees of freedom (see footnote 28). The 1994-2010 estimates are normalized for a 10-year period (see text).

Table A4: Least Squares Regression Results for Grazing Land by Buffer Width and Time Period, with Cluster-Robust Standard Errors and Clustering at the City Level

Variable	Estimate	Std. Error	p-value	Estimate	Std. Error	p-value
		1994-2010			2000-2010	
			Countywide			
Intercept	0.067*	0.030	0.04	0.067*	0.003	0.04
Ventura	0.008	0.038	0.83	0.008	0.038	0.83
Post-UGB	0.019	0.016	0.25	-0.002	0.009	0.82
Ventura×Post	0.159*	0.063	0.02	0.101	0.055	0.08
No. Obs.		14,691			12,371	
R-squared		0.03			0.01	
			0-1 miles			
Intercept	0.115*	0.040	0.01	0.115*	0.040	0.01
Ventura	-0.001	0.070	0.99	-0.001	0.070	0.99
Post-UGB	0.007	0.018	0.69	-0.013	0.022	0.57
Ventura×Post	0.209**	0.040	<0.005	0.203**	0.067	0.01
No. Obs.		2,866			2,469	
R-squared		0.05			0.01	
			0-2 miles			
Intercept	0.152**	0.040	<0.005	0.152**	0.040	<0.005
Ventura	-0.053	0.058	0.37	-0.053	0.058	0.37
Post-UGB	0.003	0.023	0.90	-0.022	0.022	0.33
Ventura×Post	0.199**	0.045	<0.005	0.182**	0.057	0.01
No. Obs.		4,909			4,231	
R-squared		0.04			0.02	

** indicates significance at the 1% level; * indicates 5% level

Notes: Critical values are from the student-t distribution with 9 degrees of freedom (see footnote 28). The 1994-2010 estimates are normalized for a 10-year period (see text).