



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

**"Green Acres? Cannabis agriculture and rural land values in Northern California"**

**Benjamin Schwab, Kansas State University, [benschwab@ksu.edu](mailto:benschwab@ksu.edu);  
Van Butsic, University of California Berkeley**

***Selected Paper prepared for presentation at the 2017 Agricultural & Applied Economics Association  
Annual Meeting, Chicago, Illinois, July 30-August 1***

*[Preliminary Draft: Do not cite without permission]*

*Copyright 2017 by Benjamin Schwab and Van Butsic. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.*

# **“Green Acres? Cannabis agriculture and rural land values in Northern California”**

Benjamin Schwab<sup>\*</sup>, Van Butsic<sup>2</sup>

<sup>1</sup> Department of Agricultural Economics, Kansas State University. 310 Waters Hall, Manhattan, KS 66506.

<sup>2</sup> Department of Environmental Science, Policy and Management. University of California Berkeley. 130 Mulford Hall #3114, Berkeley CA, 94720-3114, USA, [vanbutsic@berkeley.edu](mailto:vanbutsic@berkeley.edu)

\* Corresponding author

## **Abstract**

Cannabis production is a rapidly expanding industry in many rural communities. While cannabis production may increase the economic wellbeing of the growers, it is unclear how the spread of cultivation sites will affect property prices. On one hand, licit cannabis production should increase the value of land, as the ability to grow cannabis increases returns to land ownership. On the other, the presence of cannabis grows that may be associated with crime or environmental damage may lower property values, particularly on properties owned for amenity values. Using a dataset of property transactions in Humboldt County, we estimate the effect of cannabis grows on land prices using several estimation strategies. Our results indicate that on average parcels in parts of the county with more cannabis grows have higher prices, all else equal. We find that a change in the legal return to cannabis production stemming from a 2008 court decision further increased property prices in cannabis producing watersheds. Finally, properties eligible for a permitting system developed in 2016 saw their values increase substantially relative to ineligible parcels. Overall, our results support the hypothesis that cannabis production has been a driver of increasing land values in Humboldt County.

**Keywords: Land Values, Cannabis, Hedonic, GIS, California, Regulation**

# Introduction

Over the last half century, many rural areas in the United States have undergone broad social and cultural transformations. Behind much of these changes lies a shift in land use (Radeloff, Hammer, & Stewart, 2005). Amenity values, development potential, commodity prices and productive capacity largely determine rural land prices, and ultimately their use. For rural lands used in timber and agricultural production, capacity and expected future commodity prices play primary roles (Ferguson, Furtan, & Carlberg, 2006; Henneberry & Barrows, 1990). For rural lands that are used as second homes or recreational properties, amenities – such as proximity to lakes, scenic views, or pristine ecological settings– drive pricing (Netusil, 2005; Spalatro & Provencher, 2001). In many rural areas, both commodities and amenities play a role in land prices and may interact in price formation.

Cannabis production is an increasingly important rural land use in many parts of the country (Németh & Ross, 2014; Short Gianotti, Harrower, Baird, & Sepaniak, 2017) . Now legal as either medicine or for recreational purposes in over 30 states, cannabis production is a multi-billion dollar industry and much of the production takes place in rural areas where traditional natural resource uses mingle with the new wave of economic activities (Arcview Market Research, 2014). Further, there is increasing evidence that outdoor production takes place in ecologically sensitive areas, and there are concerns about water diversion and the use chemical inputs (Bauer et al., 2015; Carah et al., 2015; Gabriel et al., 2012). Therefore, production of cannabis as a commodity may have negative externalities that are of particular interest for amenity minded landowners

Here, we examine the impact of cannabis production on rural property values in Humboldt County, CA, the largest cannabis producing county in the country and also home to both productive and recreational rural lands (Decorte, Potter, & Bouchard, 2011). Land prices have been rising steadily over the past several decades (Figure 1), and media reports have regularly attributed price rises to cannabis production.<sup>1</sup>

---

<sup>1</sup> See, for example, Houston (2017): “Marijuana market spikes land prices in Humboldt”

We note that lands that are best for cannabis production will be impacted by two competing forces. On one hand, areas with high cannabis capacity should have higher prices if potential returns to growing cannabis, relative to other uses, are highest in these areas. On the other hand, these areas may have social and ecological disamenities that provide downward pressure on property values (e.g. higher levels of crime, transient workers, polluted streams etc...).

To estimate the effect of cannabis on property prices we use a dataset of arms-length property transactions of rural land between 1990 and 2016, data on the location of cannabis farms and an estimated amount of production from areas near the farms. We also include spatial and environmental characteristics of the properties which may impact productive capacity or recreational value. We then estimate the impacts of cannabis production using three different identification strategies.

The first, a traditional hedonic pricing model, estimates the impact of cannabis by including the density of local cannabis production as a predictor of sale price alongside standard property price determinants. This strategy is motivated by previous evidence of strong clustering of cultivation sites in the county (Butsic & Brenner, 2016a). The second utilizes a change in the legal framework surrounding cannabis production in California as a result of an appeals court ruling in 2008 (i.e. the *Kelley* decision). The change eliminated certain local and state limits on ‘personal use’ cultivation sites, thereby expanding the potential profitability of production. We use this change, an exogenous shift in the potential revenue potential from cannabis, to determine the extent to which property prices were differentially impacted in areas suitable for cannabis cultivation. Finally, in 2016, Humboldt County enacted a land use ordinance that explicitly legalized the commercial production and sale of cannabis under a regulated permit system. Only parcels that meet specific criteria related to environmental and soil characteristics are eligible to receive permits. We use the parameters of the law to identify eligible parcels, and estimate the impact of cannabis production using a difference in difference approach.

Using these methods, we find the density of cannabis production has a positive relationship with property prices. Our results based on the *Kelley* decision identification strategy suggest that a doubling of the median existing cannabis density in a watershed is associated with an 8 percent increase in the sales price of undeveloped land in Humboldt County. Finally, we find the

introduction of a permit system to produce cannabis legally caused sales prices of eligible properties to nearly double relative to ineligible properties.

## Methods

### *Study area*

We examine rural sales transactions in Humboldt County. Humboldt County is located in northern California (Figure 2) along the Pacific coast and is considered the leading cannabis producing county in the United States, if the not world. The county is heavily forested with a mix of coniferous and hardwood forest, with pockets of open rangeland. Timber production contributes about \$72 million in direct sales (Humboldt County, 2015) in the county and historically has been a major center of economic activity. Due to the steep terrain and poor soils, traditional agriculture is limited to a relatively small area of the county. Livestock, dairy, and nursery production are the largest agricultural sectors (\$76, \$61, and \$41 million dollars in sales in 2014) and make up over 95% of all agricultural production by value. In comparison, the wholesale value of cannabis production is likely over \$300 million, although no official figures exists (Butsic & Brenner, 2016b).

Second home ownership and tourism is an increasing important part of the Humboldt County economy. Located less than four hours from the Bay Area and comprised of scenic terrain and ample coastline, Humboldt County is an attractive area for outdoor enthusiast. Redwoods State park and parts of Redwoods National forest are well known for their spectacular old growth forest and attract nearly three-quarters of a million visitors a year. These visitors spend nearly \$3.2 billion dollars a year, making tourism one of Humboldt County's leading industries and second home ownership quite common.

Within Humboldt County, much of our analysis is focused on 54 randomly selected watersheds in Humboldt County for which we have spatially explicit data on cannabis production. These watersheds are representative of the area as a whole (see Butsic & Brenner 2016, for comparative statistics).

### *Cannabis production*

California allows the legal cultivation of cannabis for medicinal purposes, although the federal government still considers cannabis an illegal Schedule I drug (McGreevy, 2015). Producers must be documented care givers and can supply their crop either to individuals who have physician approval to use cannabis or to dispensaries, which can sell cannabis to patients. In 2016, California voters approved a ballot measure legalizing the recreational use of marijuana,

but that will not be implemented until 2018. Under the Obama administration, federal law enforcement agencies did not strongly enforce federal cannabis laws in states permitting its use, although there is precedent for federal actions on dispensaries and growers (Zilversimt, 2016). Federal law typically enforces a 5-year prison sentence for cultivation sites larger than 99 plants, hence anecdotal evidence suggests that some farmers do not exceed that number in case of federal intervention (California Normal, 2016). Currently there is no organized program in California to track cannabis cultivation siting, production, or sales, even in the legal market. New laws passed in 2015 aim to establish such a system by 2018 (McGreevy, 2015).

Detailed research on the actual practices of cannabis producers is scant in the scientific literature (Carah et al., 2015). Nevertheless, researchers have anecdotally observed several tendencies of cannabis production relevant to our analysis. First, production takes place both outdoors and in greenhouses. Outdoor production is reliant on natural sunlight and plants are typically grown in groups or individually in raised beds. Greenhouse production allows for light to be diminished with shades or enhanced with artificial light. While soil quality is an important driver of cropping for most agricultural products, poor-quality agricultural soil covers nearly 90% of Humboldt County. Therefore, many growers import soil for both outdoor and greenhouse grows.<sup>2</sup>

Past land use analysis have shown that cannabis production is clustered at the watershed scale, with some watersheds having high levels of production and others no production at all (Butsic & Brenner, 2016b). Cannabis production is most prevalent in the south and east of the county. Most production takes place in remote areas of the county, many of which are not suited for traditional agricultural production (Butsic et al. 2017).

Disamenities have been reported from cannabis production. Many cultivation sites are located off the grid, and thus rely on generators for power. Many Humboldt County landowners have complained about the constant humming in remote areas of the county caused by these generators (Stansberry, 2016a). Also many growers use artificial lights to increase yield, and these lights can lead to light pollution that may be unattractive to rural residents (Stansberry, 2016b). Some ranchers have also reported livestock killed or injured by dogs used to protect grows (Stansberry, 2016c; *The Times Standard* 2016). And overall, there may be an unease for some potential landowners about purchasing property near cannabis cultivation, both for cultural reasons and because cannabis cultivation is still federally illegal.

---

<sup>2</sup> While exact figures of the extent of soil importation is unknown, various local businesses supply soil in large quantities (e.g. [www.humboldtnutrients.com](http://www.humboldtnutrients.com), [www.royalgoldcoco.com](http://www.royalgoldcoco.com))

## ***Data***

Our primary dataset of property sales between 1990 and 2016 in Humboldt County was purchased from CoreLogic. We examine sales of unimproved land either zoned for agriculture (including pasture), forest, or timber, or designated as being used for those activities by the county assessor. We limited our dataset to these 1,509 sales because we were not able to obtain detailed information on improvements, such as the size of a structure, number of bathrooms, or number of bedrooms. Further, our goal is to concentrate on undeveloped properties with the potential to be converted to cannabis production.

In order to identify what features of the property impacted sales price we merged the sales data with a host of spatial variables. For each parcel we calculated: the % of the property in coniferous forest, the % in hardwood forest, the % in mixed forest, % in agriculture, and % in barren land (USDA, 2013); the distance to the nearest town of at least 10,000 people, the size of the parcel in acres, the distance to the ocean, latitude, and distance from nearest paved road. In addition we calculated the % of the parcel with slope over 30%, and percent of the parcel with a southern aspect. We also identified the zoning of each parcel (Table 1)<sup>3</sup>.

Because cannabis is often produced on imported soils and takes little land to grow, many variables typically used to explain agricultural productivity may not fully account for whether an area is actually well suited for cannabis production. Therefore, to quantify if a parcel is well suited for cannabis production, we identified the density of cannabis plants in each of the 54 watersheds for which we have data on cannabis production. To do this, we used the dataset developed by Butsic and Brenner (2016).<sup>4</sup> Cannabis density in a watershed acts as a proxy for overall suitability of a watershed for cannabis production.

## ***Identification Strategy***

Our most general model uses a basic hedonic specification to estimate the effect of a large number of co-variables on sale price. The effect of cannabis is identified by a variable which calculates the number of cannabis plants located a certain distances around the parcel. The number of plants within a given distance provides a measure of both the potential negative amenity effects of cannabis cultivation and perhaps an indicator of a particular parcel's suitability for cannabis production. Because we only have cannabis data at one point in time

---

<sup>3</sup> For the Hedonic specifications, properties with multiple parcels in different zoning statuses were assigned the largest zoning status. However, cannabis permit eligibility is based on the existence of any eligible zoning status within the property.

<sup>4</sup> The watersheds sampled for cannabis use cover approximately 60 percent of the transactions in our data.



(2012) and we also assume that cannabis production has increased over the study time period, we estimate the effect of cannabis production for each decade separately. We expect that the coefficient on our cannabis measure may change over time.

Second, we exploit a change in California state law in 2008 to identify effects of cannabis on property prices. Prior to 2008, cannabis growers were restricted by quantitative limits on the amount of cannabis authorized under the definition of ‘personal’. Those limits were codified in a 2004 bill (SB420) that specified law enforcement guidelines for personal use: a maximum of 6 mature or 12 immature plants. Therefore, if a farmer wanted to grow, for example, 98 plants, she would require medical cannabis cards from 17 patients. The *Kelly* decision, later upheld by the California Supreme Court, struck down the use of those guidelines as a basis for conviction of marijuana related offenses. The court ruled that the state of California had no legal basis to impose any quantitative limits on the number of plants a patient needed under California’s legalization of personal use cultivation. Therefore, under state law, the *Kelly* decision freed growers to increase the size of their cultivation. The decision thus lowered the legal risk associated with more intense cultivation, thereby increasing the potential return to a given parcel used for cannabis production.

The sudden change in the per acre return to cannabis cultivation provides an opportunity to test whether land values in Humboldt County do indeed respond to the cannabis market. Under the traditional ‘net returns’ framework, we would expect areas more suited to cannabis production to experience higher relative increases in per acre sales prices than non-cannabis areas after the *Kelly* decision. However, if disamenity impacts dominate, we should see lower relative prices for cannabis production areas post-*Kelly*, as more intensive production increases the associated negative externalities. We exploit this policy change by using a difference in difference specification comparing sales prices of parcels in high and low cannabis intensity watersheds sold before and after 2008.

Our final identification strategy relies on the adoption of the Commercial Medical Marijuana Land Use Ordinance (CMMLUO) (Humboldt County, 2016). The CMMLUO, adopted unanimously by the Humboldt County Board of Supervisors on January 26, 2016, created a permitting process for the production and distribution of cannabis in the county. Beginning in February, the county began accepting permit applications, and received 2,337 separate applications by the end of the year. The ordinance was enabled by California’s passage of the Medical Marijuana Regulation and Safety Act (MMRSA), which explicitly defined a regulatory structure for medical marijuana that included a local permitting process. Humboldt

County was the first California county to enact land use regulations consistent with MMRSA. In order to participate in the legal medical marijuana market, growers in Humboldt County would require a permit under CMMLUO.

The CMMLUO defined eligibility requirements for both new and existing cultivation sites, with some differences depending on whether the parcel is located in a coastal or inland zone.<sup>5</sup> For new sites on parcels greater than 5 acres, the cultivation area must be (a) located on “Prime Agricultural Soil”, (b) in a zoning districts classified<sup>6</sup> as RA (Rural Residential Agriculture), AE/AG (Agricultural Exclusive/General), FP or DF (flood plain zones), FR (forestry recreation), or U (unzoned), and (c) on slope of 15% or less, and (d) have a documented water right (or non-diversionary water source).

Existing sites (as of Jan 1, 2016) can be grandfathered in to the permitting process on more lenient terms. Parcels with existing cultivation can be permitted even in TPZ and TC zones, as long as they provide a written report from a registered forester stipulating that the site is compliant with Forest Practices Act. They also are not subject to the same soil and slope restrictions. However, permits for preexisting sites do not allow expansion of the existing grow area. Crucially, the permits are transferable to new owners in the event of a sale of the parcel.

We use the passage of CMMLUO as an additional means to identify the impact of cannabis cultivation on real estate prices. Our identification strategy rests on the fact that the ordinance affected only parcels deemed eligible for a cannabis permit, and that ineligible parcels would not have been affected by its passage. Because eligibility is based on time invariant characteristics (e.g. soils, slope), any change in the post-ordinance difference between eligible and ineligible parcels should be due to factors associated with the return to a cannabis permit. We implement this strategy using a straightforward difference-in-difference (DD) estimator. Our basic approach to estimation given by the following equation:

$$\ln(p_i) = \beta_0 + \beta_1 Post + \beta_2 Elg_i + \beta_3 PostXElg_i + \beta_4 X_i + e_i$$

Where  $p_i$  is the per-acre sales price of property  $i$ ,  $Post$  is a dummy variable equal to one if the sale of the property occurred after the enactment of the ordinance, and  $X_i$  is a vector of control variables that describe the geophysical and zoning characteristics of the property. As noted in the discussion of the *Kelly* decision, cannabis related properties appear to have changed

---

<sup>5</sup> We summarize the areas of the ordinance critical for the analysis here, which focuses on large outdoor cultivation. The ordinance details lengthy requirement for indoor and smaller grows, as well, which involve different permit types.

<sup>6</sup> The zoning district restriction is stricter in coastal areas, as only AE or RA zones are allowed.

before and after 2008. Therefore, we use only sales from the post-*Kelly* era. Visual inspection of pre-treatment trends for eligible and ineligible parcels suggest that they stabilize and become parallel after this period. In order to control for time specific effects, we also include year dummies or eligibility group specific time trends.

We construct two difference versions of the eligibility ( $Elg_i$ ) variable: *Elg* and *Elggrand*. The difference in the variables is how we consider exceptions to the eligibility requirements for existing cannabis operations. In our most basic specification, *Elg*, we include in the treatment group properties that meet the zoning, size, slope, and soil requirements specified in the ordinance. For *Elggrand*, we also include in the treatment group parcels that have an existing grow (as confirmed by our data), meet the size and zoning requirements, but do not meet the soil and slope requirement. While such properties are technically grandfathered in to the permitting process, those seeking an exception for an existing site must have registered their site within 180 days of the enactment of the ordinance in order to successfully apply for a permit. Therefore, the treatment group from *Elggrand* may be overly broad, as it includes properties that were transacted without registration. Another drawback of the *Elggrand* specification is that accounting for the existence of cannabis forces us to use our smaller set of properties that were included in the cannabis sampling, which results in a loss of approximately 40 percent of the sales in our estimation sample. Finally, because our cannabis cultivation variable relies on 2012 satellite images, *Elggrand* would also omit some parcels that have had an established grow between that time and 2016.

## Results

### *Basic hedonic model*

We first estimate a basic hedonic model as a means of describing the determinants of sale price in our sample, as well as the baseline relationship between land prices and cannabis production. We estimate separate models for each decade, either including or excluding watershed fixed effects, in Table 2.

The log of the number of plants within one kilometer of the transacted property ( $\log P1KM$ ) has a generally positive relationship with the log of the sales price per acre over all estimations. The magnitude of the effect is largest during the 1990s and during the most recent decade. As the cannabis density is measured during 2012, we would anticipate a strong relationship in the current decade, but the strong effect in the 1990s is a surprise. We explore the timing of the effect further below. The current decade estimates without watershed fixed effects imply that a 100 percent increase in nearby cannabis density is associated with a 3.5 percent increase in a property's sales price.

Several other relationships are worth noting. The variable *legal*, which denotes a prime agricultural parcel, has a strong positive relationship with sales price, particularly since the turn of the century. Timberland also appears to be significantly less valuable than other types of properties. Relative to those properties zoned for residential agriculture, properties in a timber production zone (TPZ) are 50 to 200 percent less valuable on a per acre basis, on average. Properties zoned for forest or recreation (FR) have a negative relationship of similar magnitude.

In Butsic et al (2017), we find that cannabis cultivation tends to be located in marginal areas with low potential productivity for traditional agricultural areas. In particular, cultivation sites are usually far from roads, on slopes, and close to other sites. Therefore, we would predict that areas with high current production densities were likely to be originally located on less valuable land. If cannabis cultivation is indeed raising property values, the relationship between current planting density and land prices should rise over time, though the estimates in Table 2 provide conflicting evidence for this pattern.

To further explore the relationship between contemporary cannabis density and past sales price, we estimate the standard hedonic regression in 2-year increments and plot the coefficient on our cannabis variable ( $\log P1KM$ ) in **Figure 3: Estimated sales price elasticity of current cannabis production in Humboldt county across time..** The estimates reveal a distinctive pattern: the positive relationship during the 1990s is drive by large, but very

imprecisely estimated, sales from the early part of the decade. Excluding these sales, the relationship is indistinguishable from zero during much of the 1990s and 2000s, and steadily increases during the past decade. That pattern is consistent with the idea that cannabis and land values are positively linked, but is certainly not dispositive. In the following sections, we explore identification strategies with a more plausible causal interpretation.

### ***Kelley decision***

The 2008 *Kelley* decision removed state limits on permissible cannabis cultivation, and therefore increased the potential return to cannabis production on a given parcel. We use the timing of this decision to test whether land prices appreciation is indeed related to cannabis agriculture. Our specification regresses the log of per acre prices on the same variables included in the hedonic specification, as well as a dummy variable, *PostK*, equal to one if a sale occurred after the district court decision, and the number of cannabis plants per acre in a watershed (*numplants*). In addition, we include an interaction term *numplantsXPostK*, in which our measure of cannabis density in a given watershed is multiplied by the dummy for a sale occurring after the *Kelley* decision. A positive and significant coefficient on the interaction of cultivation intensity and the post-Kelley time period indicates that the relationship between cannabis cultivation and property values became higher after the court decision. Assuming our contemporaneous measure of cultivation is monotonically related to the pre-decision distribution, this would suggest that higher potential net returns to cannabis are indeed partially driving price appreciation. Previous work (Butsic et al 2017) has shown a high degree of clustering among cultivation sites, which is likely to stem from a historic development process driven in part by reliance on strong information, distribution and social networks. Therefore, the assumption concerning the correlation of current and future cultivation sites is not quite as strong as it would be for other farm types, whose output choice is less tied to existing networks.

We first graph the trends in sales price per acre for watersheds in the highest cannabis quartile (“High cannabis areas”) and the lower quartiles (“Low cannabis areas”) using a lowess smoother. (Figure 4). In our estimation sample, sale prices in high cannabis areas lagged behind low cannabis areas until 2011. However, trends were largely similar in both areas until late in the first decade of the 2000s. The change in trends corresponds roughly with the *Kelley* decision, which occurred on May 22, 2008 (the red line in Figure 4). After this date, property values in low cannabis areas flatten, while corresponding values in high cannabis areas increased

sharply.<sup>7</sup> Put differently, low cannabis areas were affected in an expected manner by the general real estate downturn associated with the financial crisis of 2008, while high cannabis areas remained seemingly immune.

The results of our first specification, in which we interact the cannabis density of a watershed with the indicator for a sale after the court case, largely conforms to the story suggested by the graph. The OLS estimate of the interaction term in Table 3 is positive and significant regardless of whether watershed-specific time trends are included or not. To interpret the magnitude of the coefficient of the more conservative estimate, .54, note that the median watershed in our estimation sample has a cannabis plant density of .15 per acre. Therefore, our estimates suggest that, at the median, a doubling of cannabis production causes an approximately 8 percent appreciation in land values.

In Table 4, we estimate the same equation using quantile regression. These estimates both provide a check to ensure that a few large outliers are not driving our results, and also provide an indication of which sales drive the estimates. We find largely similar results, with a clear indication that the post-*Kelly* rise in sale prices attributable to cannabis occurred among properties whose sale price was in higher conditional quantiles.

#### ***Commercial cannabis land use ordinance.***

Our final set of estimations exploit the passage of a land use ordinance that created a permitting process for cannabis producers. Eligibility for a permit is based on zoning district and time-invariant geophysical and environmental characteristics of the property. We define two eligibility variables, *elg* and *elggrand*. The former does not account for the potential for existing grows to be grandfathered into a permit on more lenient terms, while the latter does. We discuss the advantages and disadvantages of each specification more thoroughly in the previous section.

As before, we use a Lowess smoother to depict the trends in prices among eligible and ineligible properties (Figure 5) before and after the introduction of the ordinance (red line). Trends by property type stabilize and progress in parallel starting in 2008. As a result, we restrict the pre-treatment period in our estimation to begin in 2008. After the introduction of the ordinance, ineligible properties appear to suffer a marked downturn, while eligible properties move in the opposite direction. However, there is a slight departure from parallel movements even prior to the January 26, 2016 ordinance, as eligible properties appear to climb slightly in

---

<sup>7</sup> The specification in logs shows very similar relative patterns. We graph trends in levels for expositional clarity.

value. These trend estimates, however, do not control for any characteristics of the sample composing the sales in each year.

Regression results from the DD specification using the *Elg* definition of the treatment group indicate that sale prices of properties eligible for a cannabis production permit increased relative to those not eligible (Table 5). The magnitude of the effect is large, ranging from a 49 to 98 percent increase, depending on the inclusion of group-specific time trends. As before, we may worry that outliers are overly influential in the estimates, especially given the fact that our data has relatively few eligible properties sold after the ordinance took effect. Quantile regressions results, however, also estimate a large impact of the ordinance on eligible properties, ranging from 79 percent at the lower quartile, to 95 percent at the upper quartile (Table 6).

Results from the specification that account for the potential grandfathering of existing cultivation sites are also positive, but smaller and less precisely estimated. However, given the reduced sample size from being limited to properties in our cannabis sample, the greater imprecision is to be expected. The OLS estimates range from a 27 percent to 56 percent relative increase in eligible properties as a result of the ordinance, with the latter significant at the 10 percent level (Table 7). Quantile regression estimates are even less precisely estimated, but of similar magnitude to the OLS (Table 8).

While the difference between the two estimates may be driven simply by the discrepancy in the sample composition, it may also reflect the fact that cannabis-related property value increases linked to permitting are driven by new operations. Indeed, anecdotal evidence suggests that some existing growers may prefer to remain in the shadows, and that demand for legal authorization is higher among more well capitalized growers. That may also explain the downturn in property values for ineligible parcels after the introduction of the ordinance. If the excess demand for land was driven primarily by those interested in participating in the licit cannabis supply chain, the ordinance likely caused ineligible properties to lose potential bidders.

## Discussion

Rural land use and economies continue to change. Here, we investigate the impact of an expanding and economically important land use: cannabis production. Using Humboldt County as our case study, we used several methods to estimate the impact of cannabis production on property prices. Our findings suggest that the increases in productive capacity of land brought about by cannabis production outweigh negative disamenity impacts of cannabis production and that returns to cannabis have a positive and statistically significant impact on property prices in our study area. While our results use exogenous variation in returns to licit cannabis production to identify the impact of cannabis production on land values, they suffer from the usual weakness of studies that rely on property sales data in that values are derived solely from explicitly transacted properties. Further, as we do not have panel data on cannabis prevalence in the county, we are unable to explicitly determine precisely how property values react to temporal changes in cannabis production levels.

The past decade has seen significant changes to state and local policy towards cannabis, and the next decade will likely bring further transitions to the regulatory framework surrounding its production and consumption (Polson, 2013; Short Gianotti et al., 2017). In California, a ballot measure passed in the fall of 2016 has legalized recreational cannabis and prompted considerable discussion of the future role of cannabis in the state's economy (California Normal, 2017). While much of the policy debate has centered on potential tax revenue from retail level sales, our research considers potential secondary impacts on the rural economy may be large, especially as they relate to the value of property.

Our results show not only that cannabis likely increases property prices, but also that as regulations make legal growing more legitimate, properties that fit the legal profile required to become permitted have increased at ever accelerating rates. As more communities codify land use regulations regarding cannabis growing, we may see similar increases in other geographic locations (Fuller, 2017). Whether or not such property premiums remain in place over a longer term may hinge, at least in part, on the enforcement of such land use regulations and whether growers perceive that the benefits of participating in the legal market outweigh the regulatory compliance and tax costs.

Property price increases, such as the ones we estimate after the 2016 ordinance, have the potential to be disruptive in many ways. Of particular interest may be the competition for land between cannabis growers and other agricultural practices. The land use ordinance explicitly



encourages cannabis cultivation in prime agricultural areas, increasing competitions for these scarce properties. That may potentially price out other more traditional land uses such as ranching or row crop agriculture. For young farmers looking to start a non-cannabis operation, such prices may make investments in land prohibitively expensive.

Finally, the large increase in prices we estimate that result from the land use ordinance makes one wonder if a property bubble around cannabis production may be forming. Many people have maintained that cannabis can grow just as well in other locations in California, and that Humboldt Counties reputation as a cannabis center is based more on tradition than any actual comparative advantage. If this is the case, we may see property prices decline in the future as growers locate to areas that provide a higher return.

## **Acknowledgements**

We thank audience members at the 2016 Redwoods symposium for helpful suggestions, Sponsored Projects for Undergraduate Research for funding and research assistance, and Ralph Armah for excellent research assistance, as well.

## References

- Arcview Market Research. (2014). *The State of Legal Marijuana Markets, 3rd Edition*.
- Bauer, S., Olson, J., Cockrill, A., van Hattem, M., Miller, L., Tauzer, M., & Leppig, G. (2015). Impacts of surface water diversions for marijuana cultivation on aquatic habitat in four northwestern California watersheds. *PloS One*, 10(3), e0120016. <http://doi.org/10.1371/journal.pone.0120016>
- Butsic, V., & Brenner, J. C. (2016a). Cannabis ( *Cannabis sativa* or *C. indica* ) agriculture and the environment: a systematic, spatially-explicit survey and potential impacts. *Environmental Research Letters*, 11(4), 44023. <http://doi.org/10.1088/1748-9326/11/4/044023>
- Butsic, V., & Brenner, J. C. (2016b). Cannabis (*Cannabis sativa* or *C. indica*) agriculture and the environment: a systematic, spatially-explicit survey and potential impacts. *Environmental Research Letters*, 11(4), 44023. <http://doi.org/10.1088/1748-9326/11/4/044023>
- California Normal. (2016). *CALIFORNIA NORML Advice for Medical Marijuana Providers*.
- California Normal. (2017). California NORML Guide to AUMA. Retrieved May 23, 2017, from [http://www.canorml.org/Cal\\_NORML\\_Guide\\_to\\_AUMA](http://www.canorml.org/Cal_NORML_Guide_to_AUMA)
- Carah, J. K., Howard, J. K., Thompson, S. E., Short Gianotti, A. G., Bauer, S. D., Carlson, S. M., ... Power, M. E. (2015). High Time for Conservation: Adding the Environment to the Debate on Marijuana Liberalization. *BioScience*, 65(8), 822–829. <http://doi.org/10.1093/biosci/biv083>
- Decorte, T., Potter, G., & Bouchard, M. (2011). *World Wide Weed: Global Trends in Cannabis Cultivation and Its Control*. Ashgate Publishing.
- Ferguson, S., Furtan, H., & Carlberg, J. (2006). The Political Economy of Farmland Ownership Regulations and Land Prices. *Agricultural Economics*, 35(1), 59–65.
- Fuller, T. (2017). Marijuana Goes Industrial in California. *The New York Times*.
- Gabriel, M. W., Woods, L. W., Poppenga, R., Sweitzer, R. A., Thompson, C., Matthews, S. M., ... Clifford, D. L. (2012). Anticoagulant rodenticides on our public and community lands: spatial distribution of exposure and poisoning of a rare forest carnivore. *PloS One*, 7(7), e40163. <http://doi.org/10.1371/journal.pone.0040163>
- Henneberry, D. M., & Barrows, R. L. (1990). Capitalization of Exclusive Agricultural Zoning into Farmland Prices. *Land Economics*, 66(3), 249–258.
- Houston, W. (2017). Marijuana market spikes land prices in Humboldt. *The Californian*. March 27.
- Humboldt County. (2015). Humboldt County Agricultural Commissioner. Retrieved January 1, 2015, from <http://humboldtgov.org/623/Agricultural-Commissioner>
- Humboldt County. (2016). Medical Marijuana Land Use Ordinance | Humboldt County, CA -

- Official Website. Retrieved May 23, 2017, from <https://humboldt.gov.org/2124/Medical-Marijuana-Land-Use-Ordinance>
- McGreevy, P. (2015). California Sets New Rules for Medical Pot Industry. Retrieved January 1, 2015, from <http://www.latimes.com/local/political/la-me-pc-gov-brown-on-medical-marijuana-regulations-20151009-story.html>.
- Németh, J., & Ross, E. (2014). Planning for Marijuana: The Cannabis Conundrum. *Journal of the American Planning Association*, 80(1), 6–20. <http://doi.org/10.1080/01944363.2014.935241>
- Netusil, N. R. N. (2005). The Effect of Environmental Zoning and Amenities on Property Values: Portland, Oregon. *Land Economics*, 81(2), 227–246.
- Polson, M. (2013). Land and Law in Marijuana Country: Clean Capital, Dirty Money, and the Drug War's Rentier Nexus. *PoLAR: Political and Legal Anthropology Review*, 36(2), 215–230. <http://doi.org/10.1111/plar.12023>
- Radeloff, V., Hammer, R., & Stewart, S. (2005). Rural and suburban sprawl in the US Midwest from 1940 to 2000 and its relation to forest fragmentation. *CONSERVATION BIOLOGY*, 19(3), 793–805.
- Short Gianotti, A. G., Harrower, J., Baird, G., & Sepaniak, S. (2017). The quasi-legal challenge: Assessing and governing the environmental impacts of cannabis cultivation in the North Coastal Basin of California. *Land Use Policy*, 61, 126–134. <http://doi.org/10.1016/j.landusepol.2016.11.016>
- Spalatro, F., & Provencher, B. (2001). An analysis of minimum frontage zoning to preserve lakefront amenities. *LAND ECONOMICS*, 77(4), 469–481.
- Stansberry, L. (2016a). Lawsuit Settled, but HUMMAP Wants More | News Blog. Retrieved from <http://www.northcoastjournal.com/NewsBlog/archives/2016/07/08/lawsuit-settled-but-hummap-wants-more>
- Stansberry, L. (2016b). Bye, Bye Night Sky | The Week in Weed | The Journal. Retrieved from <http://www.northcoastjournal.com/humboldt/bye-bye-night-sky/Content?oid=3787331>
- Stansberry, L. (2016c). Drug Mules and Dogs | News Blog. Retrieved from <http://www.northcoastjournal.com/humboldt/drug-mules-and-dogs/Content?oid=3635566>
- The Times Standard. (2016). Cow Mauled by Dog Put Down in Latest Attack; Sheriff Points to Illegal Pot Grows. *Times-Standard*, March 8.
- USDA. (2013). LANDFIRE. Retrieved December 10, 2015, from <http://www.landfire.gov/index.php>
- Zilversimt, M. (2016). Obama's medical marijuana prosecutions probably aren't legal. Retrieved August 8, 2016, from [http://www.slate.com/articles/news\\_and\\_politics/jurisprudence/2016/04/obama\\_s\\_medical\\_marijuana\\_prosecutions\\_probably\\_aren\\_t\\_legal.html](http://www.slate.com/articles/news_and_politics/jurisprudence/2016/04/obama_s_medical_marijuana_prosecutions_probably_aren_t_legal.html)

**Table 1: Variables used for estimation as well as source of data**

<b>Variable</b>	<b>Definition</b>	<b>Data Source</b>
<i>Price/acres</i>	Sale Price divided by parcel size	CoreLogic
<i>Sale year</i>	Year of property sale	CoreLogic
<i>Parcel size</i>	Size of parcel in hundreds of acres	Humboldt County parcel layers ( <a href="http://www.humboldt.gov/201/Maps-GIS-Data">http://www.humboldt.gov/201/Maps-GIS-Data</a> )
<i>numplants</i>	Number of plants per acre in each watershed	Calculated from Butsic&Brenner 2016
<i>logP1km</i>	Log of number of plants with in one KM of the property	Calculated from Butsic&Brenner 2016
<i>Legal</i>	Meets soil and slope requirements for prime ag area	Humboldt County parcel layers ( <a href="http://www.humboldt.gov/201/Maps-GIS-Data">http://www.humboldt.gov/201/Maps-GIS-Data</a> )
<i>Elg</i>	Meets soil and slope requirements for prime ag area and is located in a cannabis eligible zone (see text)	Humboldt County parcel layers ( <a href="http://www.humboldt.gov/201/Maps-GIS-Data">http://www.humboldt.gov/201/Maps-GIS-Data</a> )
<i>Elgrand</i>	Has an existing cannabis cultivation site and is located in a cannabis eligible zone (see text)	
<i>Slope 30</i>	Percent of parcel with slope greater than 30%	Humboldt County parcel layers ( <a href="http://www.humboldt.gov/201/Maps-GIS-Data">http://www.humboldt.gov/201/Maps-GIS-Data</a> )
<i>Percent mixed forest</i>	Percent of parcel in mixed forest	
<i>Percent hardwood</i>	Percent of parcel in hardwood forest	
<i>Percent shurb</i>	Percent of parcel in shrub land	CalVeg ( <a href="http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192">http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192</a> )
<i>Percent coniferous</i>	Percent of parcel in coniferous forest	
<i>Percent barren</i>	Percent of parcel barren	
<i>Inroaddist</i>	Distance of parcel to road in km	derived from road layer from Humboldt GIS ( <a href="http://www.humboldt.gov/201/Maps-GIS-Data">http://www.humboldt.gov/201/Maps-GIS-Data</a> )
<i>Distance to stream</i>	Distance to nearest stream or waterbody in KMs	California Department of Fish and Wildlife ( <a href="https://www.wildlife.ca.gov/Data/GIS/Clearinghouse">https://www.wildlife.ca.gov/Data/GIS/Clearinghouse</a> )
<i>Aspect</i>	% of parcel with South, Southeast or Southwest aspect	Derived from DEM provided by Humboldt County GIS
<i>THP</i>	Equal to 1 if a Timber Harvest Plan was on the parcel at any time between 1997-2012)	CALFIRE <a href="http://calfire.ca.gov/resource_mgt/resource_mgt_fo">http://calfire.ca.gov/resource_mgt/resource_mgt_fo</a> <a href="http://calfire.ca.gov/restpractice_gis">restpractice_gis</a>
<i>Distance to ocean</i>	Distance to ocean in hundred KMs	California Department of Fish and Wildlife ( <a href="https://www.wildlife.ca.gov/Data/GIS/Clearinghouse">https://www.wildlife.ca.gov/Data/GIS/Clearinghouse</a> )
<i>Northness</i>	Y coordinate in meters	Calculated in ArcGIS
<i>Distance to city</i>	Distance to city in in hundred of KMs	Humboldt County parcel layers ( <a href="http://www.humboldt.gov/201/Maps-GIS-Data">http://www.humboldt.gov/201/Maps-GIS-Data</a> )
<i>Multsale</i>	Multiple parcels in one property sale	Core Logic

**Table 2: Impact of nearby cannabis plants and property attributes on log of per acre property price, by decade (1990 to 2017)**

	1990-1999		2000-2009		2010-2016	
logP1KM	0.101 (0.028)**	0.116 (0.051)*	0.030 (0.014)*	-0.004 (0.021)	0.035 (0.012)**	0.009 (0.018)
Parcel Size (acres)	-0.004 (0.001)*	-0.003 (0.001)*	-0.005 (0.001)**	-0.005 (0.001)**	-0.002 (0.001)*	-0.002 (0.001)**
Acres <sup>2</sup>	0.000 (0.000)*	0.000 (0.000)	0.000 (0.000)**	0.000 (0.000)**	0.000 (0.000)*	0.000 (0.000)*
Legal	-0.086 (0.528)	-0.352 (0.882)	0.944 (0.231)**	0.755 (0.291)*	0.741 (0.214)**	0.702 (0.244)**
Slope 30	-0.267 (0.692)	0.543 (0.998)	-1.090 (0.441)*	-1.051 (0.476)*	-0.309 (0.325)	0.074 (0.318)
% mixed forest	-0.043 (0.745)	0.612 (1.145)	0.167 (0.349)	0.182 (0.479)	0.051 (0.248)	-0.014 (0.232)
% hardwood	0.059 (1.006)	0.211 (0.984)	0.184 (0.440)	0.108 (0.583)	-0.049 (0.339)	0.293 (0.329)
% shrub	1.618 (2.638)	2.181 (6.503)	0.429 (0.873)	0.794 (1.035)	-1.435 (1.183)	-1.291 (1.229)
% coniferous	-0.872 (0.602)	0.111 (0.886)	0.506 (0.331)	0.399 (0.412)	-0.067 (0.380)	0.661 (0.440)
% barren	0.396 (1.477)	-0.597 (1.962)	3.072 (4.304)	2.928 (5.093)	-1.038 (1.099)	-0.416 (1.185)
ln(Distance to road)	0.113 (0.467)	0.305 (0.678)	-0.187 (0.211)	0.076 (0.316)	-0.081 (0.148)	0.116 (0.199)
Distance to Stream	0.384 (0.204)	0.208 (0.287)	0.033 (0.115)	-0.010 (0.149)	0.082 (0.166)	0.103 (0.182)
Aspect	0.744 (0.530)	2.078 (0.833)*	-0.574 (0.285)*	-0.378 (0.351)	-0.130 (0.252)	-0.071 (0.293)
THP	0.441 (0.546)	0.273 (0.612)	0.463 (0.251)	0.193 (0.274)	-0.314 (0.245)	-0.168 (0.309)
Ag Exclusive Zone	-1.164 (0.714)	-1.289 (1.229)	-0.968 (0.322)**	-1.023 (0.445)*	-1.303 (0.269)**	-1.642 (0.301)**
Ag/Grazing zone	-0.043 (0.752)	-0.318 (1.113)	0.136 (0.411)	0.206 (0.542)	-0.279 (0.292)	-0.341 (0.379)
Timber Production Zone	-0.459 (0.551)	-1.554 (1.130)	-1.195 (0.368)**	-0.952 (0.481)*	-1.694 (0.266)**	-2.044 (0.328)**
Forest/Rec zone	-1.211 (0.691)	-2.530 (1.150)*	-0.861 (0.392)*	-0.652 (0.559)	-1.379 (0.331)**	-1.683 (0.584)**
Unzoned	-0.682 (0.578)	-1.622 (0.950)	-0.671 (0.337)*	-0.764 (0.510)	-1.484 (0.246)**	-2.142 (0.361)**
Distance to ocean	-2.912	1.254	-1.503	-3.381	-1.243	-3.717

(hundreds of KMs)	(1.376)*	(5.395)	(0.657)*	(2.052)	(0.838)	(1.483)*
Northness	0.008	-0.081	0.002	0.008	-0.000	0.008
	(0.006)	(0.086)	(0.002)	(0.008)	(0.003)	(0.005)
Distance to city	-0.705	-6.038	0.098	0.348	-0.045	-0.288
(hundreds of KMs)	(0.339)*	(3.260)	(0.167)	(0.691)	(0.162)	(0.418)
Multsale	0.718	0.840	0.341	0.289	-0.390	-0.422
	(0.525)	(1.053)	(0.212)	(0.244)	(0.264)	(0.261)
$R^2$	0.57	0.80	0.57	0.67	0.52	0.67
$N$	104	104	223	223	258	258
WS FE	No	Yes	No	Yes	No	Yes

Dependent variable is log of per acre price in 2015 USD and estimation excludes one percent tails of dependent variable distribution. All estimations control for year of sale. Omitted zone is Residential Agriculture. Variable definitions in table 1. Robust standard errors in parentheses. \*  $p < 0.1$  \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

**Table 3: DD Estimates from *Kelly* Decision**

	Log of Price Per Acre	
NumplantsXPostK	0.540 (0.181)***	0.737 (0.356)**
$R^2$	0.59	0.60
$N$	788	788
WS FE	Yes	Yes
Trend	No	Watershed

Dependent variable is log of per acre price in 2015 USD and estimation excludes one percent tails of dependent variable distribution. All estimations control for year dummies as well as all other controls in the baseline estimate from table 2. Standard errors clustered at the watershed level. \*  $p < 0.1$  \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

**Table 4: Quantile DD from *Kelly* Decision**

Quantile	Q=.25	Q=.5	Q=.75
NumplantsXPostK	0.199 (0.299)	0.517 (0.235)**	1.180 (0.425)***
$R^2$	0.51	0.53	0.52
$N$	788	788	788
WS FE	Yes	Yes	Yes
Trend	No	No	No

Dependent variable is log of per acre price in 2015 USD and estimation excludes one percent tails of dependent variable distribution. All estimations control for year dummies as well as all other controls in the baseline estimate from table 2. Standard errors clustered at the watershed level. \*  $p < 0.1$  \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

**Table 5: DD Estimates of Impact of Ordinance on Land Prices: *Elg***

	Log of Price Per Acre	
ElgXPost	0.492 (0.295)*	0.982 (0.355)***
$N$	691	691
Group Time Trend	No	Yes

Treatment group is all parcels that meet requirement for a permitted new cultivation site. Dependent variable is log of per acre price in 2015 USD and estimation excludes one percent tails of dependent variable distribution. All estimations control for year dummies as well as all other controls in the baseline estimate from table 2. \*  $p < 0.1$  \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .



**Table 6: Quantile DD Estimates of Impact of Ordinance on Land Prices: *Elg***

Quantile	Q=.25	Q=.5	Q=.75
ElgXPost	0.791 (0.252)***	0.805 (0.239)***	0.949 (0.464)**
<i>N</i>	691	691	691
Group Time Trend	Both	Yes	Yes

Treatment group is all parcels that meet requirement for a permitted new cultivation site. Dependent variable is log of per acre price in 2015 USD and estimation excludes one percent tails of dependent variable distribution. All estimations control for year dummies as well as all other controls in the baseline estimate from table 2. \*  $p < 0.1$  \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

**Table 6: DD Estimates of Impact of Ordinance on Land Prices: *Elggrand***

	Log of Price Per Acre	
ElggrandXPost	0.265 (0.276)	0.559 (0.332)*
<i>N</i>	421	421
Group Time Trend	No	Yes

Treatment group is all parcels that meet requirement for a permitted new cultivation site or a parcel with an existing site in the appropriate zone. Dependent variable is log of per acre price in 2015 USD and estimation excludes one percent tails of dependent variable distribution. All estimations control for year dummies as well as all other controls in the baseline estimate from table 2. \*  $p < 0.1$  \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

**Table 7: Quantile DD Estimates of Impact of Ordinance on Land Prices: *Elggrand***

Quantile	Q=.25	Q=.5	Q=.75
ElggrandXPost	0.261 (0.409)	0.485 (0.311)	0.466 (0.484)
<i>N</i>	421	421	421
Group Time Trend	Yes	Yes	Yes

Treatment group is all parcels that meet requirement for a permitted new cultivation site or a parcel with an existing site in the appropriate zone. Dependent variable is log of per acre price in 2015 USD and estimation excludes one percent tails of dependent variable distribution. All estimations control for year dummies as well as all other controls in the baseline estimate from table 2. \*  $p < 0.1$  \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

## List of figures

Figure 1: Trends in sales price per acre in Humboldt County CA (prices in 2015 USD).

Figure 2: Cannabis production in Humboldt County CA

Figure 3: Estimated sales price elasticity of current cannabis production in Humboldt county across time.

Figure 4: Trends in sale price per acre in high quartile (“High cannabis areas”) and the lower quartiles (“Low cannabis areas”) watersheds.

Figure 5: Sale price of rural land before and after the establishment of the commercial cannabis cultivation land use ordinance.

Figure 6: Trends in sales price per acre in Humboldt County CA (prices in 2015 USD).

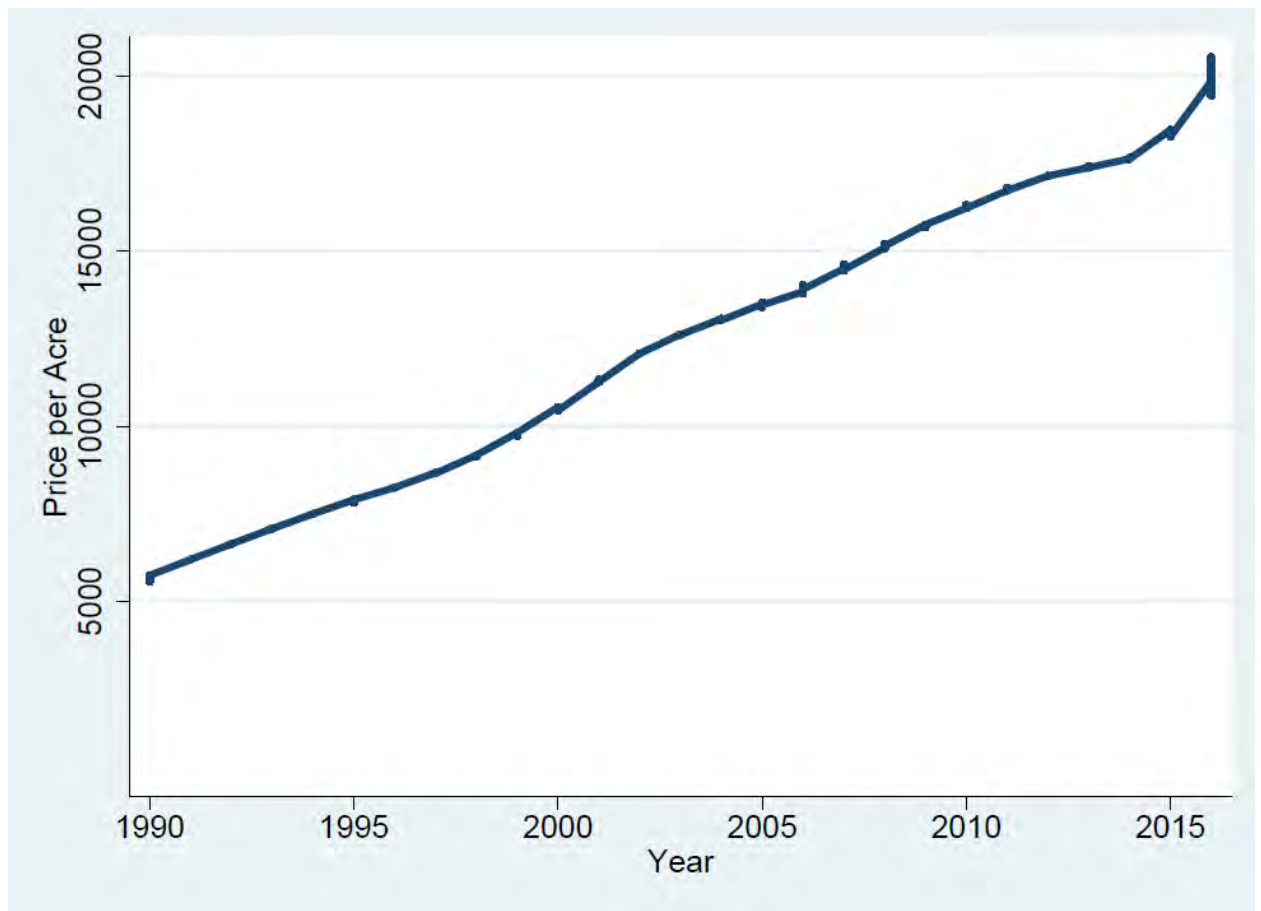


Figure 7: Cannabis production in Humboldt County CA

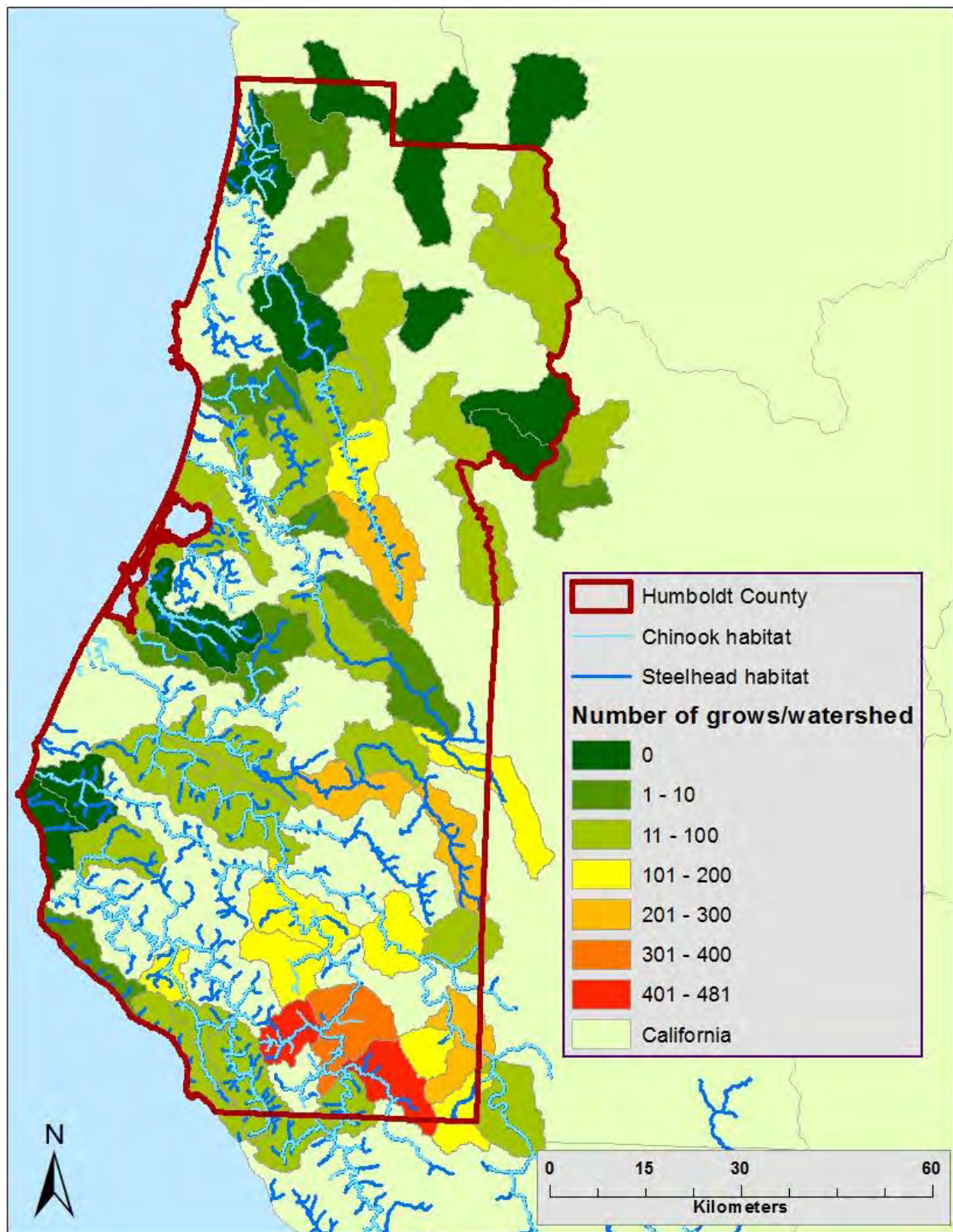
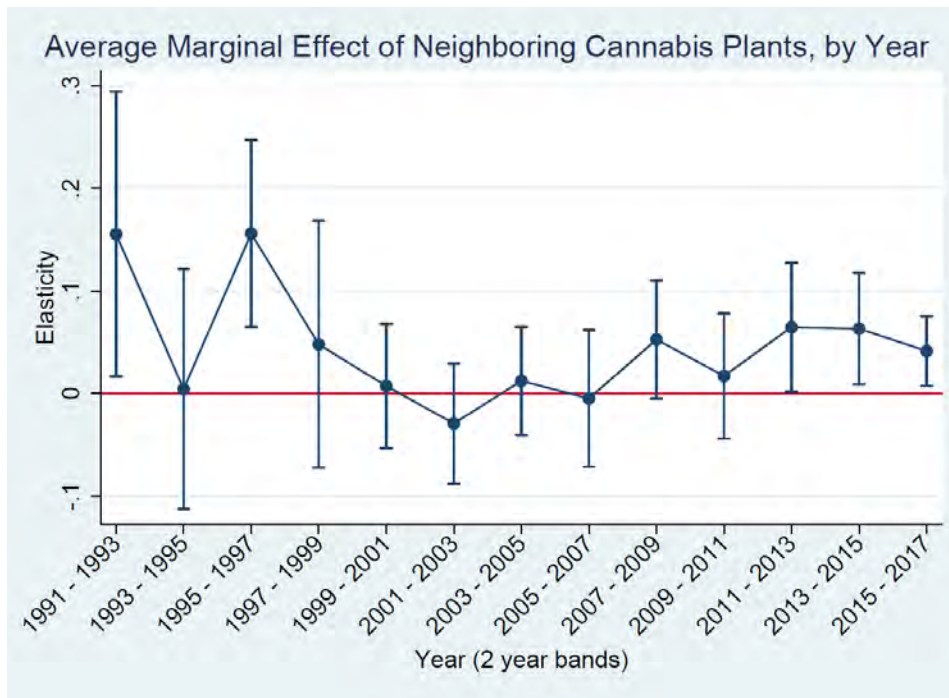


Figure 8: Estimated sales price elasticity of current cannabis production in Humboldt county across time.

Panel A: Including watershed fixed effects



Panel B: Excluding Watershed Fixed Effects

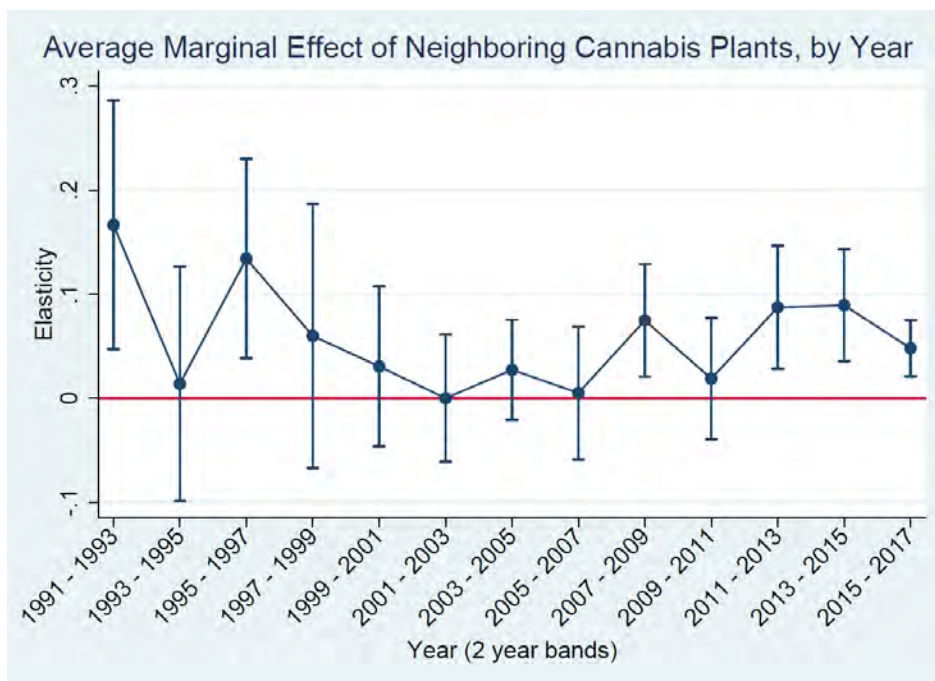


Figure 9: Trends in sale price per acre in high quartile (“High cannabis areas”) and the lower quartiles (“Low cannabis areas”) watersheds

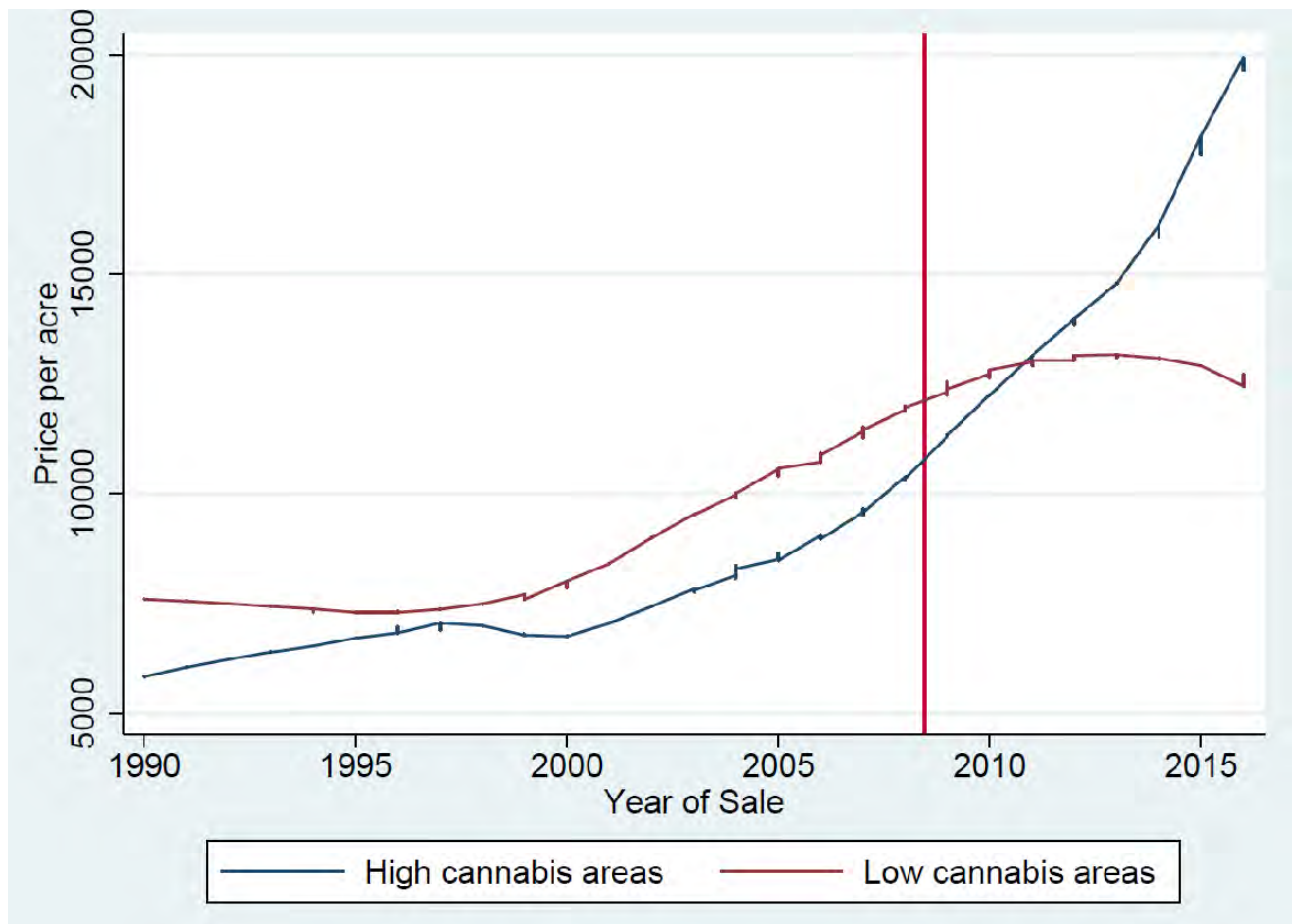




Figure 10: Sale price of rural land before and after the establishment of the commercial cannabis cultivation land use ordinance

