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# Variation in Environmental Regulations in California and Effects on Dairy Location

**Stacy Sneeringer and Regina Hogle**

In recent decades, urban encroachment and increasing environmental regulation have impacted California's dairy industry. A complicated set of environmental legislation affects dairies in the state, and can differ depending on location, creating the possibility for within-state pollution havens. This article details the regional, state, and federal environmental regulation of California's dairy industry, and examines data to see if it matches a hypothesis of regulation affecting dairy location. Using county-year data, we show evidence of changing dairy location within the state matching times of local legislative action. The Central Valley gained production, while the more regulated and urban-affected Los Angeles area lost. Large dairies have increased by 150 percent in the Central Valley, even as the number of small farms in the region declined by 40 percent. More rigorous analysis is necessary to discern the relative impacts of land prices and regulation on dairy location.

**Key Words:** pollution haven, California, dairy, environmental regulation

Pollution havens occur when one region has less environmental regulation than another region, leading "dirty" industries to grow in more pollution-friendly locations. Generally, pollution havens are associated with international trade, with localized pollutants accruing in less-regulated countries. Unifying agreements are necessary to regulate pollution across regions. In the United States, cross-state pollution havens are thought to be mitigated by federal policy. Likewise, localized pollution havens within states can be mitigated by state-level standards. While a burgeoning literature has examined international pollution havens and the effects of cross-state differences in environmental regulations, little has examined the effects of within-state variation in regulations.

California has witnessed a number of legislative changes surrounding environmental regula-

tion of dairies. While the entire state is subject to specific state and federal regulatory action, there is variability in rules at the regional level as well. This variation in regulatory activity has been chronicled in the press, as it encourages dairies to move from areas with more stringent regulation to areas with less. However, little empirical evidence examines the changes in dairy production within the state as these regional regulations are adopted.

In this article, we examine the legislative variations over time and region within the state of California to discern whether this variation could have contributed to industry location changes within the state. We provide a detailed description of the environmental regulations of dairies between 1970 and 2007. To get a basic understanding of how this regulatory activity impacted dairy location within the state, we examine several measures of dairy location and production. With county-year data, we examine basic trends of where cattle are located in California over time in order to discern trends pre- and post-regulations. We hypothesize that if we can discern noticeable trend breaks at the time of regulation, regulatory activity has had a significant effect on cattle location. Additionally, we examine data

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from several Censuses of Agriculture to provide a more detailed understanding of how regulation has impacted dairy location.

We find that there is significant variation within the state and over time with respect to not only total number of milk cows but also density of cows per square mile. Trend breaks in where milk cows are located occur at times of regional legislative action, suggesting that these activities had an impact on where dairying occurred within the state. Between 1982 and 2002, the Chino region saw declines in the number of dairies, while the Central Valley saw increases in the number of dairies with over 500 head but declines in the number of dairies with fewer than 100 head. Both regions also saw declines in the amount of land in farms, although Southern California's declines were greater. While this study provides empirical evidence of changes within the state's dairy industry that are consistent with an impact from environmental legislation, more detailed analysis would be necessary to show that these changes were driven by regulation rather than other factors, such as land prices.

### Dairy Production in California

In 2007, California led the United States in production of milk, followed by Wisconsin, New York, Pennsylvania, and Idaho. In that year there were 1.8 million dairy cows in California, producing over 40 billion pounds of milk on 2,200 operations. Dairying in California has always been at the forefront of technological innovation, and largely occurs in industrial-style settings. Nearly 88 percent of dairy cows in California are on facilities with at least 500 head.

California has witnessed significant increases in dairying, unlike the other top-producing states. Figure 1 shows the amount of milk produced in the top five dairying states between 1980 and 2007. The number of milk cows in California increased steadily in this time period as well. The reason for this steady increase in California dairying has been attributed to climate, the close proximity to complementary crops, geographic isolation, and the rapidly increasing population (Butler and Wolf 2000). In California, cows are raised predominantly in dry-lot with open barns (Bath 1969). Only a small proportion of dairies are pasture-based, located predominantly in Marin County

north of San Francisco (Guthey, Gwin, and Fairfax 2003).

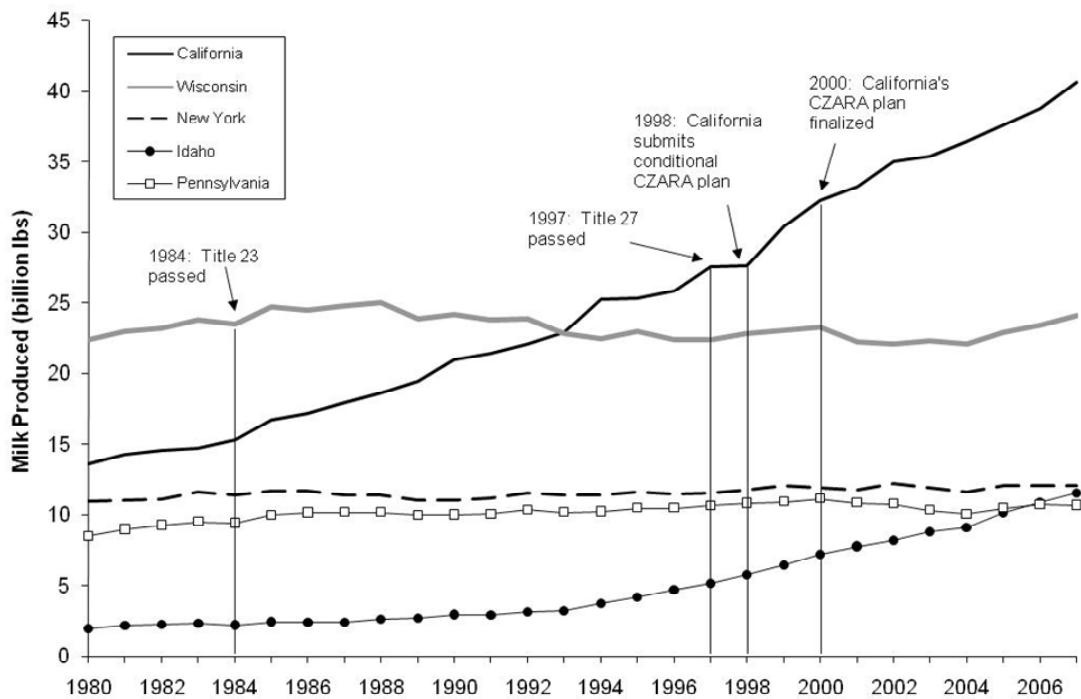
California dairying has traditionally occurred outside of the Los Angeles area and in the Central Valley. However, these patterns have been changing over time, as evidenced by Figure 2. The Central Valley has seen large increases in dairying over the past few decades, as the rest of the state has declined in its milk cows per square mile. This has predominantly been a decline in the number of small farms, thought to have been pushed out of business by increasing competition and the more efficient large-scale dairies (Stern-gold 1999, Tillison 2006, MacDonald et al. 2007).

### Pollution Associated with Dairies

The primary by-product of dairy production is manure. In large-scale production many animals are raised in a relatively small amount of space, which yields a vast quantity of manure in a concentrated location. At confinement facilities, liquid waste is pumped into man-made ponds called "lagoons" for storage. Some of the manure can be used as fertilizer, although this is dependent on the availability of land. Land application of manure must be managed carefully so as not to lead to nutrient over-saturation or rain-related runoff.

If waste is not handled appropriately, it can lead to pollution (Gollehon and Caswell 2000). Water pollution can occur from any wash water, manure, or other dairy waste that comes into contact with ground or surface water. Livestock production has been recognized as a contributor to water pollution at least since the 1972 Clean Water Act; this concern has led to a large body of research documenting the problem and fashioning methods to curb it (see, for example, Copeland and Zinn 1998).

More recently, attention has also focused on air pollution from dairy operations. Concern about pollutants that are harmful to human health originally received the most attention, although now greenhouse gases associated with dairy farms are also being scrutinized (FAO 2006). The primary air pollutants harmful to human health associated with dairy operations are particulates, ammonia, and volatile organic compounds. These can arise through decomposing manure, animal movement, and gas emissions from the animals themselves (Thorne 2002).



**Figure 1. Total Milk Production, Top 5 Dairy-Producing States, and Dates of California Environmental Regulations of Dairies, 1980–2007**

### Influences on the Location of California Dairies, 1980–2005

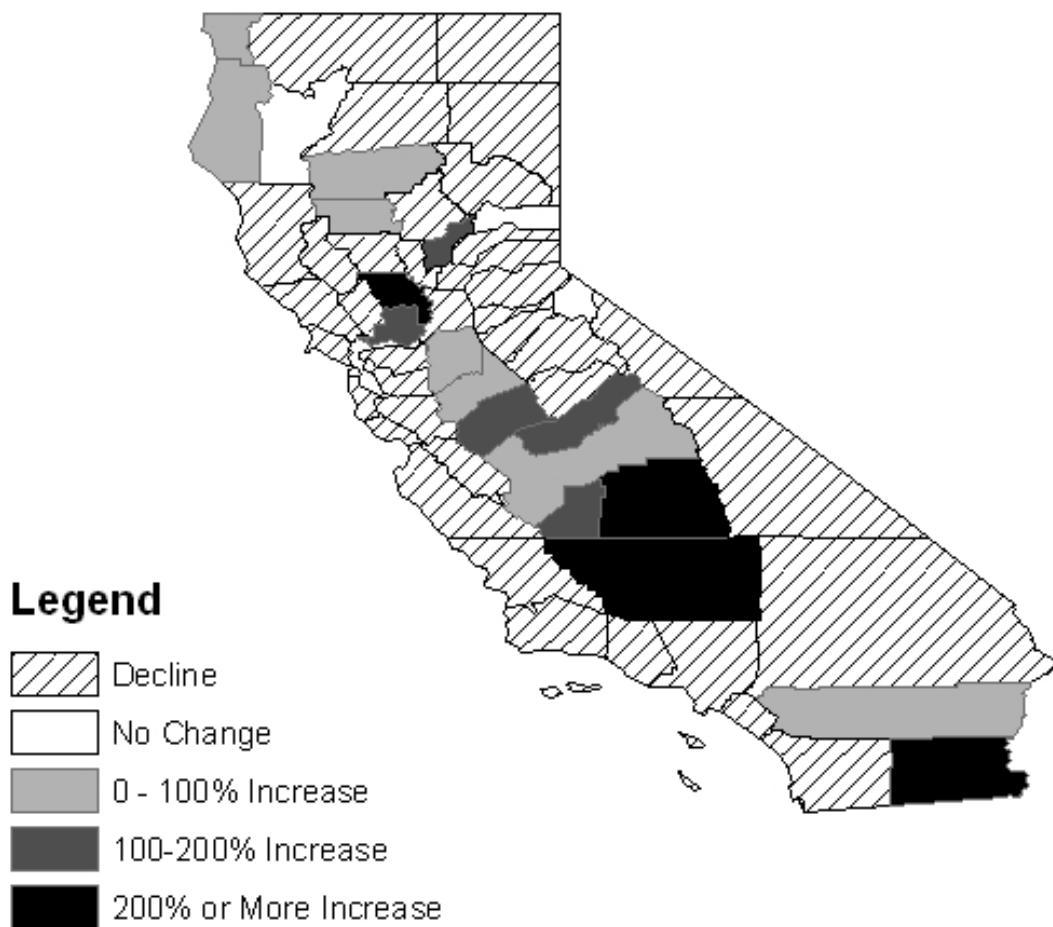
A number of academic articles have examined the effects of environmental regulations on location decisions of dairies. This work predominantly deals with cross-state differences in environmental regulation. Metcalfe (2000) documents significant variation in manure management regulations across states, and finds it to be increasing in the 1990s. A relatively early piece by Abdalla, Lanyon, and Hallberg (1995) mentions the importance of environmental regulations but does not empirically test this impact. Herath, Weersink, and Carpentier (2005) explore all livestock types and conclude that state-level environmental regulations play a significant role in location decisions of dairy. Isik (2004) finds the stringency of state-level regulations of dairy to influence location. Stirm and St. Pierre (2003) survey dairy producers across the United States and find environmental amenities and laws governing waste man-

agement to be primary factors in location decisions.

Information on the influences shaping location of California dairies between 1980 and 2005 comes predominantly from trade journals, the popular press, and sociological research. These sources describe two major influences on the location of the California dairy industry. The first is urban encroachment, particularly in the southern part of the state. Many portions of the United States are witnessing increasing urban-rural conflict, and California has long experience with this (see, for example, Medvitz, Sokolow, and Lemp 1999).

The second influence on California dairying is environmental regulation, which differs by region. Often coupled with or caused by increasing property values and population growth, increased regulatory activity means that dairy producers face heightened compliance costs.

Reports in trade journals and the popular press clearly reflect these influences. As Art Marquez,



**Figure 2. Percentage Change in Milk Cows per Square Mile, 1980–1985 to 2000–2005**

third-generation dairy farmer in Southern California, is quoted as saying in a 2004 *Associated Press* article (Molloy 2004),

With the way that the industry is moving through the more stringent regulations and rules, it doesn't make economic sense to continue in Southern California. You can sell your piece of property and move somewhere else that's more agriculture-friendly.

A 1997 report in *Feedstuffs* (Butler and Ekboir 1997) notes the development pressures and increasing environmental regulation of dairies in the Chino Valley (near Los Angeles). Western United Dairymen, a trade organization, established a service in 2007 to help members under-

stand the “rising tide of water quality regulations that threaten to swamp its members’ livelihoods” (Marsh 2007). A California Farm Bureau Federation publication noted how the dairy industry was driving land prices in the Central Valley as producers searched for areas to dispose of waste water (Kirkpatrick 2004).

#### **Environmental Regulation of Dairies in California**

Given the amount of academic research and number of trade journals revealing the importance of regulation, a rendering of the various legisla-

tion is necessary. Deanne Meyer of the University of California at Davis has written extensively on the separate regulations facing dairies (see Meyer 2003, 2005, 2007). What is needed is a grouping of these regulations together to understand potential effects on the location of California dairying. The box on page 138 provides a timeline of the local, state, and federal regulation of dairies in California. As is evident, there are myriad regulations at various government levels.

Dairies in California face significant variation in water quality regulation depending on location. Different portions of the state adopted regulations at various times. Further, separate governing bodies and pieces of legislation overlap, leading to confusion over which regulations are pertinent for which dairies. The puzzlement has become intense enough that the University of California at Davis offers classes for dairy operators to understand which regulations they must comply with, and how to go about doing so (Payne 2008). Federal and state-level legislation also use different terms. For example, consider the differences between AFOs, CAFOs, and CAFs. Federal legislation (EPA 2003) terms operations that house cattle in confinement for at least a month and a half of every year as “animal feeding operations” (AFOs). AFOs with more than 300 cattle are defined as “confined animal feeding operations” (CAFOs). AFOs with fewer than 300 cattle can be designated as CAFOs by the regulating authority if the AFOs are significant polluters of waterways. California uses the terms AFO and CAFO in the same manner as the U.S. Environmental Protection Agency (EPA), but also uses the term “confined animal facilities” (CAFs) (California State Water Resources Control Board 2007). CAFs are places where animals are corralled or otherwise tethered. CAFs therefore include both AFOs and CAFOs.

#### *Federal Regulation*

The federal government first began regulation of large-scale livestock operations in the 1972 Clean Water Act. The Clean Water Act designated CAFOs as “point source” polluters and required them to obtain National Pollutant Discharge Elimination System (NPDES) permits (EPA 2006). In order to obtain such a permit, a CAFO needed

to institute certain engineering requirements related to its waste management pond. The Clean Water Act also relegated enforcement to state authorities, so that different states could interpret the need for these permits differently. In California NPDES permits were required only if a facility intended to emit pollution into surface waters; as such, most dairies in the state were not originally asked to obtain such a permit. Even though they were not required to obtain permits, California regulations basically put the same stipulations on dairies as did the NPDES permits.

While the original Clean Water Act had specific regulations concerning point-source pollution from large-scale livestock operations, the regulation did little to control non-point source pollution, also called runoff. If manure is spread on land and then rain washes it into nearby water bodies, this is considered non-point source pollution. Eventually, this type of pollution was the source for most water-body impairments (EPA 2005). Realizing a problem with non-point source pollution, the EPA enacted further regulation aimed at this problem. The 1987 amendments to the Clean Water Act (the Water Quality Act of 1987) required increased permitting of storm water runoff from industrial facilities. These amendments required large AFOs to obtain permits after they instituted methods to control for pollution related to flooding. Enforcement was again relegated to state authorities; California adopted these permits in 1991, and implemented them in the following years (California State Water Resource Control Board 1991, Funderburk and Binderman 1993).

A second piece of legislation aimed at curbing non-point source pollution was the 1990 Coastal Zone Act Reauthorization Amendments (CZARA). To prevent runoff to coastal waters, the EPA together with the National Oceanic and Atmospheric Administration adopted the CZARA (Cope land 1999). This united sections of the Clean Water Act and the Coastal Zone Management Program and set forth guidelines for management of runoff. The guidelines dealt in large part with agricultural runoff, including nutrient pollution from livestock production. States were required to design and implement their own management plans according to the guidelines. In 1998 California submitted a conditional plan, which was finalized in 2000 (NOAA 2008).

| <b>Timeline of Regional, State, and Federal Environmental Regulation of Dairies in California</b> |   |
|---|---|
| 1970  | <i>California Porter-Cologne Water Quality Control Act</i>  |
| 1972  | <b>Federal Clean Water Act passed</b>   |
| 1972–1994   | Region 8 Water Board issues individual waste discharge requirements for each AFO                                      |
| 1982–2003   | Region 5 dairies waived from WDRs   |
| 1984  | <i>Title 23 of California Code of Regulations passed</i>  |
| 1991  | <b>Larger AFOs required to get General Industrial Storm Water Permit (Order No. 91-13-DWQ)</b>                        |
| 1994  | Region 8 Water Board adopts new waste discharge permits for dairies (Order No. 94-7)                                  |
| 1997  | <i>Title 27 of the California Code of Regulations passed; Title 23 repealed</i>                                       |
| 1998  | <i>California submits conditional CZARA plan</i>  |
| 1999  | Santa Ana Regional Board (Region 8 Water Quality Board) requires more stringent policies (Order No. 99-11)            |
| 1999  | <b>USDA and EPA finalize unified national strategy for AFOs</b>   |
| 2000  | <i>California's CZARA plan finalized</i>  |
| 2002  | <b>EPA signs new CAFO rule, requiring all large dairies to get NPDES permits and create nutrient management plans</b> |
| 2003–2007   | Region 5 Water Board attempts to create a new permit after WDR waiver expires   |
| 2004  | South Coast Air Quality Management District adopts nation's first regulation about air quality from dairy             |
| 2006  | <b>EPA begins regulation of large-scale livestock facilities under Clean Air Act</b>                                  |
| 2007  | Region 5 releases new WDR General Order for Existing Milk Cow Dairies for public comment                              |

Notes: Federal policies in bold. State policies in italics. Regional policies in normal text. See text for further explanations of policies and definitions.

Definitions: AFO: animal feeding operation / WDR: waste disposal requirement / CAFO: concentrated animal feeding operation / CZARA: Coastal Zone Act Reauthorization Amendments.

In 2003 the EPA instituted a new CAFO rule, requiring all large dairies to get NPDES permits and create nutrient management plans (Huang, Magleby, and Christensen 2005). The rule is very nearly the same as the original rule in the 1972 Clean Water Act, although it adds emphasis to non-point source pollution through the requirement of nutrient management plans, and does not allow state agencies to decide if CAFOs need permits (Meyer 2005).

In 2006 the EPA turned its attention to regulating large-scale livestock farms under the Clean Air Act. In that year the EPA entered into an agreement in which large-scale livestock operations will self-monitor emissions of air pollutants and report these to the EPA; the results will be used to regulate these facilities. At present the EPA has received over 2,600 agreements from in-

dividual livestock operations in the United States (EPA 2006).

#### *State-Level Regulation*

California water quality regulation of dairies began two years earlier than the Clean Water Act with its 1970 Porter-Cologne Water Quality Act (Ruffolo 1999). This state-level legislation divided California into nine Regional Water Quality Control Boards, which could decide regional regulations of dairies.

The next piece of state-level legislation came in 1984 with Title 23 of the California Code of Regulations (Meyer, Garnett, and Guthrie 1997). This required dairy operations to follow specific guidelines related to manure storage and land application. Manure lagoons needed to have a ca-

pacity capable of withstanding large storm events, and were required to have partially clay (and therefore less permeable) bottoms.

In 1997 the portion of Title 23 dealing with Confined Animal Operations was rescinded and replaced with Title 27. This established statewide minimum standards for CAF discharge. It required farmers to report their waste discharge or proposed waste discharge, banned animals at CAFs from entering any surface water, and required CAFs to retain all waste water generated at the facility. Title 27 also stipulated that CAFs institute proper retention pond design. The monitoring duties of these requirements were passed to the Regional Water Boards (27 CCR Section 22565).

#### *Regional Regulation*

Differences in environmental regulation of dairies within the state arises via the regional water quality boards. Since dairying has occurred predominantly in the Chino area and in the Central Valley, the water boards governing these areas created the most regulation of CAFs.

Region 8, near the Los Angeles area, is densely populated with both cows and humans, with over 340,000 head of cattle in 250 facilities (California RWQCB, Santa Ana Region, 1999). Urban encroachment and water quality legislation have gone hand-in-hand in the area. The region was the first to regulate dairies for environmental concerns, and has increased its stringency over time. Beginning in 1972, the Region 8 Water Board began issuing individual waste discharge requirements (WDRs) for each large dairy. These WDRs limited the amount of manure allowed to be spread on disposal land. At the time, these WDRs were individualized for each dairy (California RWQCB, Santa Ana Region, 1999).

By 1994, the Region 8 board had found that its specialized permits were too resource-intensive to continue. It created a general permit for all dairies (Order No. 94-7). While this move might have yielded more regulatory consistency, it apparently did not lead to clean water. In 1998 the California 303(d) List and Total Maximum Daily Load (TMDL) Priority Schedule listed several impaired waters due to CAFOs, including a number of water bodies in the Region 8 Chino Basin (California RWQCB, Santa Ana Region, 1999).

In light of these findings, in 1999 the Region 8 Water Board adopted new types of waste management plans (Order No. 99-11). These made all dairies in the region subject to National Pollutant Discharge Elimination System (NPDES) permits, required management plans for the disposal of manure, and prohibited land application of manure in the Chino Basin (even as fertilizer). The board also required that manure be removed from a dairy facility within 180 days of being removed from corrals. Finally, the order prohibited new construction of CAFOs in the region (California RWQCB, Santa Ana Region, 1999).

The late 1990s also witnessed re-zoning of areas of the city of Chino, which influenced whether it could be developed for urban uses. The 1968 California Land Conservation Act, also known as the "Williamson Act," designated specific areas as agricultural zones, encouraging the separation of home owners from dairies. Population growth and increasing urbanization in the Los Angeles area led to pressures to re-zone land previously defined as "The Dairy Preserve." Starting in 1994, the region experienced a series of complicated incorporations, resulting in dairy land being re-designated as fit for development (Rollings-McDonald 2003). This had the effect of allowing dairies to sell their land for substantial sums (\$500,000 per acre is one quote) and relocate with significantly larger herds to the north and out of state (Sterngold 1999, Oncken 2008).

A reason that dairies might have fled north to the Central Valley was its relatively weak environmental regulation. Region 5 of California covers a large portion of the state, including the dairy-rich Central Valley. This region has 1,500 dairies (California RWQCB, Central Valley Region, 2008), with Tulare County accounting for a quarter of the state's dairy production (Shultz 2000). Region 5 did not take its first regulatory step until 1982, when it waived dairies from WDRs (California RWQCB, Central Valley Region, 2007). The lack of attention to regulatory actions is reflected in a 1996 survey, which showed that dairies in the Central Valley rarely performed analyses to evaluate whether the land could handle the nutrient loading of the manure (Meyer, Garnett, and Guthrie 1997).

Apparently reliant on Title 27 for its regulation, Region 5 began to re-evaluate its waivers in 2003. In that year, a report found that Title 27 was in-

sufficient to protect groundwater (Brown, Vence, and Associates 2003); this had the effect of spurring regulatory activities by the Region 5 Water Quality Board. For the next four years, this region attempted to establish a new permit (Meyer 2002, 2003). As of 2007, Region 5 had released the new WDR General Order for Existing Milk Cow Dairies for public comment (Meyer 2007). This has spurred heated discussion with regards to the effects on dairying in the Central Valley.

More recently, air quality concerns related to dairies have begun to manifest themselves in regional regulatory activity within California, separate from the upcoming federal regulation. Similar to the water boards, California also has regional air quality boards. Like its earlier push to enact water quality regulations of dairies, Southern California was also first in enacting air quality regulations for dairies. In 2004 the South Coast Air Quality Management District adopted the nation's first dairy air quality regulation. This requires that starting in 2005, dairies must remove manure from corrals four times per year (South Coast Air Quality Management District 2004).

In 2005, the Central Valley region also showed signs of beginning to regulate dairies for air pollution. The San Joaquin Air Pollution Control District released a report updating its emission factor from dairies (San Joaquin Air Pollution Control District 2005), stating its importance in determining which facilities would be required to obtain an Air District permit.

This description of the regulation of dairies reveals regional variation over time. The question is whether this variation made an impact on where dairies located in the state. The next section describes data used to examine this possibility.

## Data

The data come from the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS). Two sets of data are used in these preliminary analyses. First, annual data by county come from the NASS's QuickStats database (available online). County annual data show all milk cows by county. Data of this type concerning milk cows covers only dry milk cows that have calved. We have no county-year measures

on the total number of cattle at dairy operations, nor the number of dairy operations.

These data are missing values for 1993 through 2000; thus, we add county-level measures from the 1997 U.S. Census of Agriculture, and perform linear extrapolations between 1992 and 1997, and between 1997 and 2001. We have state-level totals on the number of milk cows in these missing years; linear extrapolations reflect the same totals as the NASS-reported state totals. Because of this extrapolation, any trend breaks that occur in 1992, 1997, and 2001 may be artifacts of the data and not representative of any actual changes.

The second type of data used is county-level data from the 1982, 1987, 1992, 1997, and 2002 U.S. Censuses of Agriculture. Because there are only five years of data and these years are five years apart, this data is not useful in detecting trend breaks. However, the data is more detailed, enabling understanding of more specific variables.

All of the data is at the county level, for the 58 counties in California. However, the Water and Air Quality Control Boards do not overlap precisely with county borders. We therefore define regions on the basis of counties that have any part within the region. Tests of including counties fully inside the region with counties with only a part inside the region show nearly the same means. Region 8 includes the counties of Orange, San Bernardino, and Riverside. However, Orange County has very few milk cows, and thus does not impact the numbers for the region. Region 5 includes portions of 36 counties.<sup>1</sup> Eight of these counties hold nearly all of the milk cows in Region 5; these are Tulare, Kern, Kings, Fresno, San Joaquin, Stanislaus, Madera, and Merced. By 2005, these eight counties in Region 5 and the two in Region 8 accounted for over 99 percent of all milk cows in California.

Because counties have different sizes, we divide the number of milk cows by the land area in square mileage to compute a milk cow density. Regional densities are computed by summing the number of milk cows in the region's counties and

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<sup>1</sup> These include Alameda, Alpine, Amador, Butte, Calaveras, Colusa, Contra Costa, El Dorado, Fresno, Glenn, Kern, Kings, Lake, Lassen, Madera, Mariposa, Merced, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, San Benito, San Joaquin, San Luis Obispo, Shasta, Sierra, Siskiyou, Stanislaus, Sutter, Tehama, Tulare, Tuolumne, Yolo, and Yuba.

dividing by the sum of the square mileage in the region's counties.

## Results

Federal-level regulation should affect not only all states uniformly (assuming consistency of enforcement), but also all regions within a state. Therefore, federal regulations could be witnessed only if their application differed by region or state. Federal regulations would also affect all regions within a state in the same manner if enforcement were uniform. Figure 1 shows no trend break for all states at the time of federal legislation, suggesting that federal activity did not have an unconditional impact on dairy production.

Regulations at the state level conceivably affect all dairies within the state equally. Therefore, if we see declines across the state starting in a certain year, we may expect that this could be related to state-level regulations. For example, if there is a slowing of growth in the dairy industry within California in a certain year but not in other states, this suggests something particular to California. If the time period coincides with state-level regulation, this provides a stronger causal implication of state-level regulation. Examination of state-level trends does not suggest that this is the case (Figure 1).

Differences in location by regulatory timing can be witnessed at the regional level. Figure 3 shows trends in milk cow density in Region 8 and the select Central Valley counties comprising most dairying in Region 5, as well as the rest of the state for comparison. As is evidenced, Region 5 shows a fairly constant upward trend. Region 8 shows much more variation. Between 1980 and 1986, the two regions reflect a similar upward trend. However, between 1986 and 1997 Region 8 shows little change. This may be reflective of stricter enforcement in Region 8 of 1984 state-level legislation. In the mid-1990s, there is a definite negative trend break in this region, followed by a period of no change between 2001 and 2004, and then another steep negative trend break in 2004. The density changes in Region 8 coincide with regulatory changes. Region 8 adopted stricter waste management laws in 1994 and 1999, and then saw several re-zoning laws that could contribute to the drop in density between 1994 and 2001. The dip in 2004 may

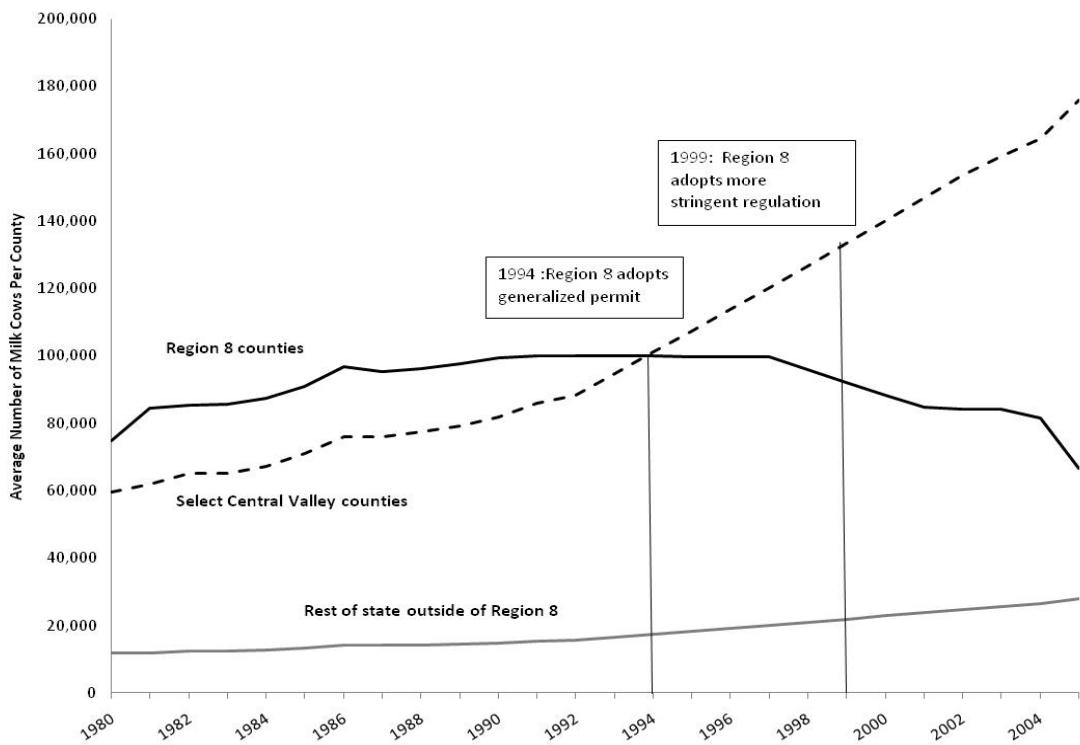
have to do with the region's adoption of air quality standards doubling the number of times that manure had to be removed from sites.

Exploration of specific counties enables a more detailed description of the changes. Figures 4a and 4b show the trends in total milk cows in ten counties that perform dairying in the state. Figure 4b shows the Region 8 counties with milk cows. Riverside County shows declines in number of cattle starting around 1989, with more precipitous declines after 2004. San Bernardino County starts declining in the late 1990s, and also shows the 2004 negative trend break. Figure 4a shows trends in the eight heavy dairy production counties in Region 5 covering nearly all milk cows. While Tulare County shows a fairly constant increase over time, trends in the other Region 5 counties mirror trends in the Region 8 counties. Kern and Fresno see positive trend breaks in 1989, suggesting that these counties receive the milk cows that Riverside loses. The 1992 trend break in Kings and Merced may be an artifact of the linear extrapolation. The 2004 positive break in Kern is also reflective of the negative breaks in Region 8 at the time.

Agricultural Census data provide more detail as to the changes in Regions 5 and 8. Table 1 provides totals for the two Region 8 counties and the eight Region 5 counties for five Census years. Between 1982 and 2002, Region 8 saw losses in dairy sales, while Region 5 gained. Small farms with fewer than 100 head declined in number in Region 8 first, followed by operations with 500 or more head. Small farms in Region 5 also became less numerous nearly every time period, even as the number of large operations increased rapidly. In both regions, the land in farms declined, although Region 8 had more marked losses. This is suggestive of the more pronounced urban encroachment occurring in Southern California. It also suggests that land for waste management is not becoming more abundant in the Central Valley over time; the increases in milk cow inventory are therefore not accompanied by more land available for waste disposal.

## Discussion and Conclusions

This article has documented the significant variation in California's environmental regulation of dairy production over time and location. Exam-



**Figure 3. Average Density of Milk Cows by Region of California, 1980–2008**

nation of state-level trends for the largest dairying states suggests that state-level regulations are not significantly hindering this industry in California. Cross-county comparisons show that Southern California is losing milk cows, while Central Valley counties gain. Trends by county suggest that Southern California milk cows are contributing to the growth of dairying in the Central Valley.

Census data reveal that the Central Valley has grown, in terms of dairy sales but also in number of large operations. This region has also seen declines in the number of small farms and slight declines in acreage in farms. This concentration of dairy production into large operations without more land for manure application points to increasing nutrient management concerns. Southern California lost both dairy sales and agricultural land. Small farms declined first in the region, followed by the large-scale dairies.

Did the more stringent and earlier regulation of Southern California dairies create a Central Valley pollution haven? Pollution havens occur if there are differences in environmental legislation

across regions, and if the “dirty” industry locates in the less regulated region *because* of these lower environmental stipulations. The literature on international pollution havens points out that more lax environmental standards are often correlated with other input features, and it is these other features that may drive location decisions. For example, lower environmental standards may be positively correlated with lower labor costs; industries operating in locations with lax environmental standards may be doing so for the lower labor input price, not the environmental regulations. Hence cross-sectional findings of “dirty” industries operating in regions with lower environmental standards do not necessarily mean that those regions are pollution havens.

Research on pollution havens has attempted to control for this possibility by using panel data and examining how changes in the location of polluting industries are related to changes in environmental standards. This research also attempts to control for other input factors, to discern the relative importance of the regulations.



**Table 1. Levels of Dairy Variables**

|                                       | 1982        | 1987        | 1992        | 1997        | 2002        |
|---------------------------------------|-------------|-------------|-------------|-------------|-------------|
| <b>REGION 8</b>                       |             |             |             |             |             |
| Number of operations with dairy sales | 420         | 366         | 355         | 279         | 216         |
| Amount of dairy sales                 | \$1,046,353 | \$927,378   | \$880,202   | \$848,926   | \$635,457   |
| Farms with milk cows                  | 545         | 425         | 379         | 306         | 246         |
| Farms with fewer than 100 cows        | 150         | 83          | 51          | 38          | 42          |
| Farms with 500 or more milk cows      | 219         | 243         | 257         | 234         | 181         |
| Land in farms (acres)                 | 2,622,522   | 2,173,514   | 1,710,659   | 1,433,046   | 1,085,678   |
| <b>REGION 5: TOP 8 COUNTIES</b>       |             |             |             |             |             |
| Number of operations with dairy sales | 1,512       | 1,472       | 1,464       | 1,361       | 1,482       |
| Amount of dairy sales                 | \$1,941,541 | \$1,879,838 | \$2,093,077 | \$2,642,845 | \$3,072,384 |
| Farms with milk cows                  | 1,916       | 1,692       | 1,636       | 1,490       | 1,608       |
| Farms with fewer than 100 cows        | 623         | 375         | 313         | 220         | 372         |
| Farms with 500 or more milk cows      | 327         | 430         | 574         | 688         | 805         |
| Land in farms (acres)                 | 10,886,592  | 10,474,925  | 10,015,946  | 9,764,189   | 9,990,355   |

This article has documented the variation in environmental regulations of dairies in California. This variation is a necessary but not sufficient condition for the development of a pollution haven. As a first step in empirically documenting the effect of regulatory activity on dairy location in California, we examine trends in the location of dairies within the state. These patterns support a hypothesis of movement based on regulation. However, we have not controlled for other features that may be driving location decisions. Most notably, we have not controlled for land prices. More rigorous analysis is necessary to understand how the relative impacts of environmental regulations, land prices, and other key input variables affect dairy location decisions within California. Ideally, we would need a scenario in which regulations change but land prices do not. It may also be possible that higher land prices and environmental regulation function in tandem in their effects on dairy location.

If regional differences in regulation are contributing to differing pollution levels, state regulators may need to consider their regulatory approach. If regulators wish to equalize the amount of pollution across the state, then allowing legislative dif-

ferences by region may not be advisable. However, there may be reason to locate all of the dairies in the Central Valley. First, this region may have more assimilative capacity to absorb pollutants, and therefore the effect of land application of manure may have less of an effect on water or air quality. Second, because this region is poorer, the gains from increased economic activity may outweigh the externalities associated with the pollution.

If we consider this scenario in terms of human health, a state-level social planner may consider exposure-dose-response connections. Since the Central Valley is less densely populated than other regions of the state, human exposure may be minimized by locating the polluting industry there. The functional form of the dose-response relationship between dairy-related pollution and health may also impact decision making. If the health response is very low or zero for low pollution levels, but then increases exponentially, then dairies should be spread out across the state so that no individual population is overly affected. However, if the dose-response relationship takes a concave functional form such that only low levels of pollution yield safe levels, while higher

levels yield extreme negative outcomes, then it would be necessary to locate the contamination source in a minimal-exposure area. More research would be necessary to ascertain these relationships to guide appropriate policy.

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