Comments on the Dairy Sector Workshop, August 22, 2024:
CADD Database and Use of the Data in the CARB

Climate Action California is pleased to present these comments, specifically on the CADD database and its use, described in the Dairy Sector Workshop on August 22 of this year. These comments were developed by Daniel Chandler, Ph.D., a co-author of Climate Action California's 2024 Petition to Regulate Dairy and Livestock Methane, and an expert in research and policy analysis; and Jonathan Cole is a data analyst and retired university professor who has published on climate change.[1]

We thank CARB for making the CADD database publicly available. We are especially grateful to Morteza Amini, Ph.D. and other CARB staff for meeting with us at length and providing answers to numerous questions.

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[1] Ramanathan, Veerabhadran, Roger Aines, Max Auffhammer, Jonathan Cole, Fonna Forman, Hahrie Han, Mark Jacobsen et al. "Learning Companion to Bending the Curve: Climate Change Solutions." (2019).

Executive Summary

In preparing California's Greenhouse Gas Emissions Inventory for the dairy and livestock sectors, CARB has used the US Department of Agriculture (USDA) Census of Agriculture as its source for data on cattle herd sizes. The Census is produced at five-year intervals; and facility-level information is not available to CARB or the public.

At the August 22, 2024 California Dairy Sector workshop, CARB staff presented a new database, the California Dairy and Livestock Database (CADD), as a possible alternative data source. CADD represents an attempt to provide annual, facility-level herd-size data from existing administrative data (primarily Water Board and Air District reports). Regrettably, our analysis and several conversations with CARB staff who developed CADD lead us to the conclusion that the CADD database has significant flaws. **Moreover, it does not include other factors that are necessary to estimate methane emissions, such as types of cattle feed and manure management practices.**

We do not understand how any robust regulatory program affecting a key California industry can proceed without complete, accurate, and verifiable data. Surely the simplest solution to the problem is the best: CARB should directly survey facility owners to elicit data that will meaningfully improve the agency's ability to estimate methane emissions from dairy and livestock facilities. With this data CARB can make informed decisions about how to proceed with incentive programs, with regulation, or a combination of the two.

Key Findings

A. Substitution of CADD data for USDA data on dairy herd size is a low-yield, high-cost and high-risk strategy.

- Low yield: CADD does not meet CARB's need for farm-specific emissions data (only herd size, which is insufficient for projecting methane emissions).
- High cost: Creating, maintaining, and updating the database is labor intensive.
- High risk: If CARB relies on this data, which is incomplete and may well be flawed, the agency could lead the state to believe 2.5 million metric tons of methane had been reduced when it has not.
- Even greater risk—to the climate as well as California's climate goals—is involved in failure to capture all the methane possible as soon as possible, which can only be assured by regulating dairies as soon as possible.

B. USDA census herd size information does not match CADD data, and there is evidence that CADD data may be unreliable.

- CADD herd size data do not correspond in number or trend with USDA Census data.
    - Federal Census information is collected directly from farmers and subject to extensive verification, so CARB must at least explain why the two data sources differ.
- CADD data is missing most of the information the USDA has on beef cattle, making it useless for calculating beef cattle emissions.

- CARB staff have confirmed to us that they will continue to use USDA census data for beef cattle emissions.
- Over time, CADD required estimation of some kinds of data for over 4,000 dairies, which was missing in the sources. This process is not transparent.
- There are many ways of verifying both herd size and digester data that have yet to be employed. Chief among these is comparison with farm-level data from a UC Riverside study that was the first to use administrative data to calculate farm-level herd sizes.
  - We used available data from CADD, the USDA, and the UC Riverside study to compare 2017 county-level data. USDA and the UC Riverside data matched well; CADD data was significantly different (both higher and lower) for many counties.
  - CADD data could also be compared with Tulare County government farm level data.
- The staff presentation was misleading in assuming that trends of the past 11 years will predict herd sizes in the next eight, especially given the many questions about missing or unverified data and the absence of information about other predictors of herd size.
- Much additional information is needed to accurately assess farm level emissions is not in the CADD data base. For example: the presence of corrals or free stalls as housing types; and the presence of flush, scrape, or vacuum systems for manure collection. In fact, CARB seems to be collecting the CADD data with no intent of using it for refining farm level emissions projections; since CADD is not accurate enough to inform statewide emissions projections, there is seemingly no clear use for the CADD system at this point.
- We have concluded that the CARB implementation is neither accurate enough to rely on nor useful for refining farm scale emissions information. In order to obtain accurate data for regulation, CARB should survey dairy and ranch owners directly – which CARB can do even without adopting regulations. We also urge CARB to empower an independent expert panel to review and provide advice on farm scale data collection that will be useful for regulation.

C. CARB's analysis of the relationship of digester use to changes in herd size is conceptually and methodologically flawed.

CADD's approach applies statistical methods that assume randomization of assignment to a treatment (having a digester). This is inappropriate for an observational study that is clearly contaminated by selection bias (who chooses to implement a digester); as a result, CADD brushed over the fact that, whatever causal factors might exist, the dairies with digesters did have a 1.3% herd increase annually. This analysis should be redone with appropriate methodology and a focus on the dairies participating in LCFS, as they are the ones for whom more manure will lead to more profit.

We conducted a preliminary version of this analysis, available in Section C, which leads us to conclude that large herd increases are not associated in general with dairies after installing a digester, nor are large increases associated specifically with dairies in the LCFS program. However, all of the weaknesses of the CADD data we present below could affect these results.

Comments on the CADD database and its use as presented in CARB's August 22 Workshop Presentation

A. Substitution of CADD data for USDA data on dairy herd size is a low-yield, high-cost, and high-risk strategy.

The California Dairy and Livestock Database (CADD) is a database compiled over the last year by CARB staff that attempts to capture herd size from every dairy[2] by obtaining administrative data from several organizations, primarily regional water boards. (See the August 22, 2024, Staff Presentation for much more detail.) Generating the information that has gone into the CADD database is a very large task and one of considerable difficulty. So far as we can judge this process was carried out meticulously. The errors that we believe exist in the CADD database are largely a function of the deficiencies of the administrative record systems it relies on.[3] We also appreciate that CARB has made the CADD data publicly available to download and analyze. In fact, this is the first public disclosure of data that has been considered proprietary in the past, and we hope there will be additional uses for it. Nonetheless it is not appropriate for judging statewide dairy methane trends.

Low Yield: We were very happy that CARB has finally recognized the need to obtain farm-level data on greenhouse gas emissions for dairy cows and beef cattle. In 2022 we discovered the UC Riverside research that is the model for what CARB has done with the California Dairy and Livestock Database (CADD). We not only tried to get CARB interested but we wrote legislation requiring it and asked Assemblyman Rivas to carry it. Unfortunately, that did not happen. We recommended the research in our Petition to Regulate Dairy Methane.[4]

Thus, we have been in favor of using administrative data to tell us about emissions on individual farms, at least as a first step toward regulation. However, after discussions with CARB staff we learned that the CADD data are not intended to be used, as they were in UC Riverside, to produce farm scale emissions estimates. CADD only contains herd size data, not other information that would enable better emissions projections.

It is unfortunate that the full UC Riverside template was not followed. The UC Riverside researchers were able to produce much more detailed projections of emissions because they collected not just herd size data but information for each farm that allows better estimation of emissions from different types of manure management.[5] This *could* be very important as the concentration of dairies increases. We see fewer and fewer cows on smaller farms (that do not produce as much methane per cow due to pasturing them) and more and more cows on concentrated animal feeding operations (CAFOs) with thousands of cows and manure lagoons, the most methane-intensive way of managing manure. But with

[2] It also contains information on beef cattle, but missing data make this part of the database unusable.
[3] In discussions between CAC and CADD staff, they stated that they do not have the resources to check the data in the administrative records against other sources. Staff do review data that appears to be missing and, in some cases, make estimates of what it would be if it had been captured by the waterboards.
[4] https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://ww2.arb.ca.gov/sites/default/files/2024-06/2024-05-30-CARB-CDFA-Response-to-Dairy-Rulemaking-Petition.pdf&ved=2ahUKEwjUn-LbzPOIAxUXFjQIHTvdDcYQFnoECBgQAQ&usg=AOvVaw2Bd_DGDyOktBf0YdQzb9lP
[5] Examples of information, beyond herd size, that UC Riverside collected are: the presence of corrals or free stalls as housing types; flush, scrape, or vacuum systems for manure collection; and mechanical separator, settling basin, or weeping wall as solid–liquid separator systems, and presence of a digester.

CADD data, CARB will be left with no better idea of the effect of herd concentration on methane emissions than it had before. The alternative to using CADD for this limited purpose is to collect information directly from dairy farmers. A relatively brief survey would permit much better understanding of emissions at each dairy.

At the same time CARB has been developing CADD, it has contracted with Ermias Kebreab, of UC Davis to develop a California-specific model of greenhouse gas emissions based on numerous variables that predict both enteric and manure emissions (CADEM). When finished, this model will enable much more precise estimates of emissions to be made, but only if detailed information is obtained from the farmers.[6]

Thus, CADD does not increase the accuracy of emissions measurement and CADEM will require data beyond even that of the Marklein/Hopkins study.

High cost: CADD data do not update themselves but require very intensive staff time. To illustrate, look at the flow chart of numerous decisions that must be made for each CADD observation (Staff presentation, page 34). This investment in time would presumably be needed through 2045. We also believe that to increase reliability of CADD, CARB would have to get agreement from all of the regional waterboards from which data are solicited, and perhaps the regional air quality districts where backup data come from, to adopt a single protocol for data collection.[7]

High-risk: CARB's purpose, regardless of what method it uses, is to measure and reduce the emissions of GHGs from dairy and beef cattle. In the staff presentation, the hypothetical reduction of an additional 22% of the methane from manure was attributed to attrition in herd sizes suggested by CADD data project out to 2030. If it were to turn out that CADD is in error in predicting so much more attrition than USDA census data do, it would mean we would have missed our mark for reductions by up to 2.5 million metric tons of methane. One would have to be extraordinarily confident in the accuracy of the CADD data to take that risk.

In addition, the CADD data seem intended to head off regulation of dairy methane. Regulation is the most certain way to reduce as much methane as possible as quickly as possible.

The low-risk, lower cost, high yield alternative: Obtain herd size and other information needed by the CADEM model through a direct survey of dairy farmers. Such a request has the legal status equivalent to a subpoena, is relatively simple and low cost, and will enable much better estimates of emissions.

B. USDA Census Herd Size Information Does Not Match CADD Data, and there is evidence that CADD data may be unreliable.

First, we must acknowledge the primacy of the US Department of Agriculture Census, which is conducted every five years. CARB's Emission Inventory uses it as the established standard. The Emissions Inventory methodology says: "The dairy cattle population is from the USDA census, which is compiled every 5 years. For the intermediate years that the USDA census does not cover, staff used the trends in

[6] https://ww2.arb.ca.gov/development-testing-standard-and-mechanistic-model-enteric-fermentation-methane-emissions

[7] See the CARB presentation page 33: "Annual report cattle categories are not consistent across different Regional Waterboards."

CDFA annual population estimates to fill in missing years." An extensive methodology section for the USDA Census details the many steps USDA goes through over a three year period to achieve an accurate list of farms. In contrast to CADD, there were also many steps to verify accuracy of data and to determine whether farms were missed. The probability of missing farms and quantitative measures of uncertainty were established. For example, the coefficient of variation for herd size was 1%.[8]

> The census of agriculture provides a detailed picture of U.S. farms and ranches every five years. It is the leading source of uniform, comprehensive agricultural data for every State and county or equivalent. Census of agriculture data are routinely used by agriculture, organizations, businesses, state departments of agriculture, elected representatives, and legislative bodies at all levels of government, public and private sector analysts, the news media, and colleges and universities….Response is required by federal law.[9]

The problem with this data source for CARB has not been accuracy but that the census only occurs every five years and farm level data is held confidential. So the census does not yield farm level data, which would be needed for regulation; but it is the best available for state totals and trends.[10]

The August 22, 2024 California Dairy Sector Workshop presented for public comment a system in which herd counts for dairies (but not beef cattle) would use the new system called the California Dairy and Livestock Database (CADD), and no longer use the federal census. After working with the CADD data, which are public, and meeting with CARB staff for two hours, we believe this would be a major misstep. There can be no justifiable introduction of a new system unless equal or greater accuracy of the new system can be proven. As we will see, however, CADD results are significantly different not only from the USDA census data but from farm scale data developed by UC Riverside scientists Alison Marklein and Francesca Hopkins using sources and methods very similar to those used in creating CADD.[11] This study will be called Vista here. Since the same sources and similar methods were used for Vista and CADD, very similar results should be obtained for years in which data collection overlapped. However, as we will see, that was not the case. Thus, CADD data is not corroborated by either the USDA or the Vista

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[8] United States Department of Agriculture. 2022 Census of Agriculture. California: State and County Data Volume 1 Geographic Area Series Part 5 AC-22-A-5. Issued February 2024, https://www.nass.usda.gov. The coefficient of variation is the ratio of the standard deviation to the mean expressed as a percentage, and is thus a measure of dispersion. The 1% coefficient of variation is quite low.

[9] https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/usintro.pdf&ved=2ahUKEwjb8_Kkg6GJAxWlLzQIHV5pPEsQFnoECBgQAQ&usg=AOvVaw1-cOc9qPeA067GxLTRUUnl

[10] www.nass.usda.gov. Definitional issues: The CA Emissions Inventory is based on the USDA Census: Dairy sector emissions in the GHG Inventory are calculated using: "Statewide population data from the USDA 5-year Census of Agriculture; Parameters from the U.S. EPA GHG Inventory methodology (e.g., excretion rate, methane conversion factor, manure management system distribution); Verified digester project data from the Low Carbon Fuel Standard and Cap-and- Trade Program (number of cows; fraction of manure sent to the digester)."

[11] Marklein, Alison R., Deanne Meyer, Marc L. Fischer, Seongeun Jeong, Talha Rafiq, Michelle Carr, and Francesca M. Hopkins. "Facility-scale inventory of dairy methane emissions in California: implications for mitigation." *Earth System Science Data* 13, no. 3 (2021): 1151-1166.

statewide systems, and there is no plausible way to show that *it* is more accurate than either of the other approaches.[12]

How do CADD herd size trends differ from those in the USDA census?

Below is a comparison of the CADD data with the USDA Census data in 2012, 2017 and 2022, the years for which federal data is available.

Exhibit 1: Comparison of USDA Census and CADD herd size data[13]

Year	USDA	Percent Change	CADD	Percent Change
2012	1,815,655	NA	1,873,805	NA
2017	1,750,329	2012-2017 = -3.6%	1,722,367	2012-2017 = -8.1%
2022	1,688,202	2012-2022 = -7.0%	1,597,736	2012-2022 = -14.7%

Both the USDA Census and CADD show a decline in dairy herd size over ten years, but the decline in CADD is about twice that in the Census data. Over the ten years of 2012 to 2022, Census data shows a total reduction of 7% while CADD shows 15%.

An initial issue is that while the CADD database contains some beef cattle CARB cannot use the CADD beef cattle data to project enteric emissions. This is because most beef cattle data has not been reported to the water boards, even though legally required. CARB staff agreed with us that the CADD beef cattle data are not usable and stated that they would continue to use USDA data to estimate statewide emissions for beef cattle.

The data on beef cattle we do have – from the USDA Census – shows that the decline in milk cows is almost completely offset by a 16.9% increase in beef cattle from 2012 to 2022. Using USDA Census data, when beef cattle and milk cows are combined the total herd size is only 1.2% less in 2022 than in 2012.

Exhibit 2: USDA Census trends in milk cows and beef cattle

USDA Census	2012	2017	2022	Percent Change 2012 – 2022
Milk cows	1,815,655	1,750,329	1,688,202	-7.0%
Beef cattle	583,594	682,372	682,020	16.9%
Total	2,401,261	2,434,718	2,372,244	-1.2%

This is relevant since CARB staff are saying that enteric emissions for cattle must still be based on the USDA Census data (as adapted by the Emissions Inventory).

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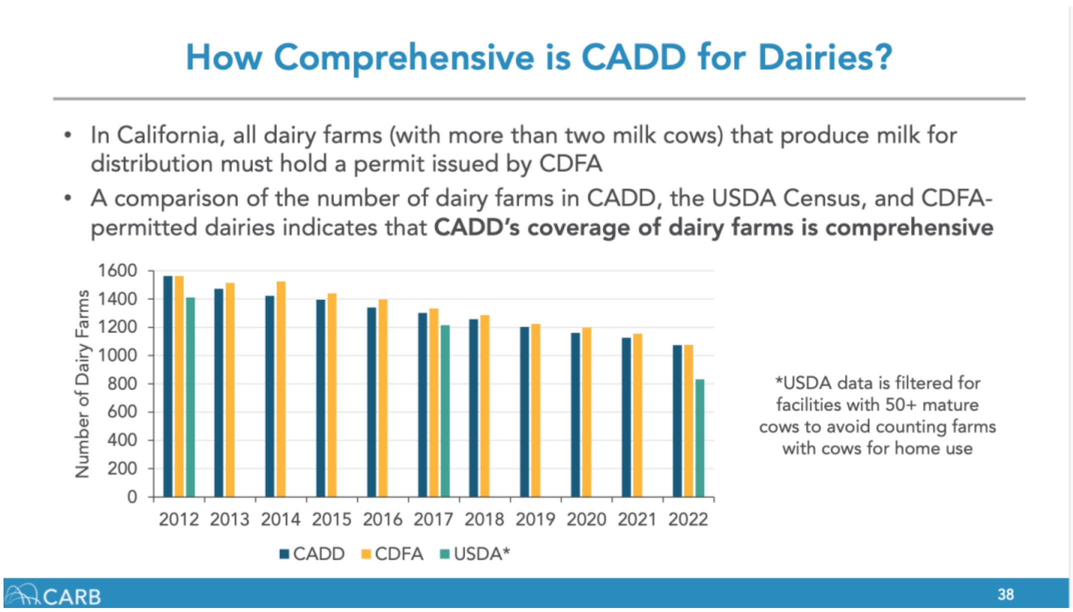
[12] While it is possible, as we note later, that the data from Vista could be compared on a farm-level, that would only be for one year. In addition, CARB staff simply accept the data from the administrative data bases. There is no way for them to verify the herd sizes. As we also note later, there are anomalies in the CADD data that make certain entries highly suspicious (e.g. dairies with 11 years in which there is no change in herd size) but no other source would allow confirmation.

[13] Here are the definitions for each data source: CARB used "mature cows," which included mature milk cows and mature dry cows. The Federal Census used this definition: "Item 2b – Milk cows - Report the number of cows of any breed kept for milk production on this operation on December 31, 2022. Include dry milk cows and dairy heifers that had calved by December 31, 2022." In this table we use all "mature cows" regardless of whether they were described as "labeled as dairy" or not.

Using CADD, CARB is in the uncomfortable position of saying USDA Census data is inaccurate for dairies but is still the accepted standard for beef cattle. In addition the USDA data is used by CDFA and many, many others for hundreds of data points about dairies beyond herd size. In fact, it is used by the CARB Emissions Inventory to assess methane emitted by rice fields, and for enteric emissions from other types of animals. To justify the substitution of CADD for USDA data there would have to be considerable evidence that the CADD data are more accurate and reliable than the USDA data. We have looked at this issue and present the results below.

Determining the number of dairies and their herd sizes: Comparing data sources

Do available sources confirm CADD's determination of the number of dairies? Here is the analysis shown in the August 22 workshop. On Slide 38 from the Staff Presentation, *the annual CDFA data for* permitted *dairy farms exceeds the number of farms in CADD data in 9 of the 11 years and is equal in the other two years.* Also CARB removed farms with less than 50 cows from the USDA data. This is not legitimate since the CDFA data count as a dairy any farm *with two or more cows*. See the graph below from the presentation:



Below, we show the number of dairies in CADD and in the USDA for the years USDA data is available: 2012, 2017, and 2020. Rather than, as in the graph above, being far below CADD and CDFA numbers, the unfiltered USDA farm numbers exceed CADD by hundreds of farms in 2012 and 2017 and are slightly higher than CADD in 2022.

Exhibit 3: Number of dairies USDA and CADD

Year	USDA	CADD
2012	1,931	1,563
2017	1,653	1,302
2022	1,117	1,074

In our conversations, CADD staff reported to us that the USDA and Vista data are not relevant for validation of CADD because those data bases do not release individual facility data. However, both have made data public at the county level. We believe it makes sense to try to validate CADD using county farm and herd size totals; hence we include a comparison of CADD with the UC Riverside Vista data and the USDA data at the state and county level for 2017 in Appendix 1 and Appendix 2.[14] This comparison shows for farm size overall:

- Farm size totals in 2017: (See Appendix 1 for county level)

  USDA = 1,538[15]
  Vista = 1,727
  CADD = 1,302

- Overall state-level total herd sizes are similar for 2017: (See Appendix 2 for county level)

  USDA =1,731,264
  Vista =1,749,812
  CADD =1,711,025

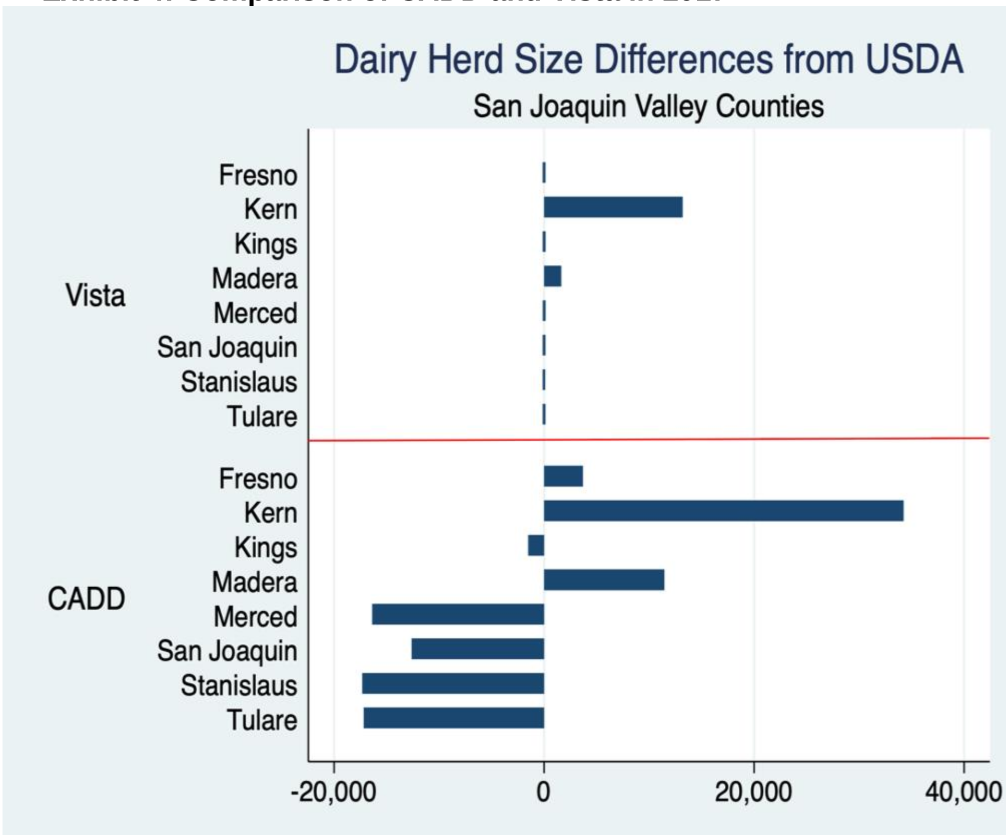
- Vista shows 189 farms more than USDA but only 18,548 more cows. For the greater number of farms, then, the herd size averages only 98 cows per farm. So it appears Vista may be registering a substantial number of small dairies than is USDA.
- Appendix 2 shows that USDA and Vista data correspond closely on most county herd sizes numbers, but CADD (which used “the same” methodology and sources as Vista) consistently underestimates herd sizes in many counties and overestimates herd sizes in a few counties; and CADD has no data at all for five counties that Vista and USDA show having herds. The graph below presents this pattern in just the eight San Joaquin Valley counties. Vista shows very close accord with the USDA data for seven of the eight counties. In general, CADD shows far greater discrepancies from the USDA data than does Vista, suggesting though not proving that CADD – although using the same administrative data sources – is less accurate than Vista.[16]

[14] The source of the county-level data for USDA and Vista is Marklein/Hopkins: Supplement of Earth Syst. Sci. Data, 13, 1151–1166, 2021 https://doi.org/10.5194/essd-13-1151-2021-supplement. The article itself is: Marklein, Alison R., Deanne Meyer, Marc L. Fischer, Seongeun Jeong, Talha Rafiq, Michelle Carr, and Francesca M. Hopkins. "Facility-scale inventory of dairy methane emissions in California: implications for mitigation." *Earth System Science Data* 13, no. 3 (2021): 1151-1166. The CADD data in the tables is from the CADD public data portal: https://ww2.arb.ca.gov/resources/documents/california-dairy-livestock-database-cadd

[15] This number differs slightly from the data USDA published in 2022 for 2017. We do not know the reason, although it is possible the data from 2017 were revised for the 2022 report.

[16] It does not seem possible that facility level data could match closely when the aggregation to the county level is this far off. However, CARB could have asked Francesca Hopkins for the facility level data to make a direct comparison but, as of this date, has chosen not to. To meet confidentiality requirements, after merging farm identifiers, the combined data set would need to be de-identified. But this is quite feasible since the CADD data are public, Francesca Hopkins could manage the merge of identifiers and then de-identify the combined data set. Also, there appear to be differences within CARB, Morteza Amini, the CADD staff team lead, is not pursuing consultation with Hopkins or comparison with her data. Michael FitzGibbon, Branch Manager of the Research Division, said it would be easy to check with Hopkins. We are unaware whether that consultation has occurred. Another chance to verify CADD data is to compare it with the data Tulare County compiles. It is available at: https://foe.org/wp-content/uploads/2024/10/2024-ACFP-List-2022-ACR-Numbers.pdf

Exhibit 4: Comparison of CADD and Vista in 2017



Discrepancies between CADD and USDA census data at a sub-county level

Tulare County has the most cows and produces the most milk of any California county. In 2022, USDA shows 187 dairies; the herd total is 480,992 milk cows. In CADD the number of dairies is 210 and the number of mature cows 437,831.

The table below shows the detailed herd size comparison for Tulare. Note that the columns show the number of dairies in each herd size category. So in the category with 1 to 9 cows, the USDA shows 3 dairies while CADD shows none. In the category with 500 or more cows, the USDA shows 177 dairies, while CADD shows 197.

Exhibit 5: Tulare farms comparison if "labeled as dairy" in 2022

Mature Cow Herd Size	USDA: Dairies	CADD: Dairies
1-9	3	0
10-19	2	0
20-49	0	0
50-99	0	0
100-199	0	2
200-499	5	11
500 or more	177	197
Total Farms	187	210
Total Cows	480,992	437,831

We have included sub-county comparisons for another four counties in Appendix 3. They generally make the same point that the Tulare data does. In two of the four counties USDA and CADD show county level herd sizes that are close, but in none of the counties do USDA and CADD show close to the same distribution of farms in the county by herd size categories.

Methodological issues in generating herd size data from administrative sources rather than a census of dairy farmers

To understand why such large discrepancies between data sources might exist we have to look at the CADD methods of obtaining and verifying information. The CADD data is not information directly reported to CARB; it is data compiled by combining several data sources where herd size is collected for different purposes. The main source is local water boards and the state Water Board. The use of administrative data for this purpose was initiated and demonstrated by Professor Francesca Hopkins and her colleague Alison Marklein at UC Riverside. Marklein describes the problems in estimating herd size with their methodology – which also applies to CADD. Her description indicates how much indeterminacy (uncertainty) there is.

> The data regarding the number of cows are proprietary information that are not consistently reported by any one agency, and the agencies do not communicate with each other….Further, the number of milk cows varies interannually (as they only lactate for part of the year and are considered dry cows the remainder of the year), and the animals are sold and traded. These factors make this information surprisingly difficult to estimate….We assume that the uncertainty in the cattle populations is 20%, as recommended by the IPCC. For dairies with cattle permits, the water quality board assumes 15% uncertainty in population (California Regional Water Quality Control Board, 2013).[17]

The actual procedures used by UC Riverside are similar to those used by CARB for CADD. The Riverside discussion, however, provides a much better picture of the difficulties of getting accurate data than the CADD presentation did.

> We determined herd population sizes primarily from the 2019 State Water Resources Control Board Confined Animal Facility fees list. However, some dairies did not pay a fee in 2019, but still have animals, so for these facilities we integrated data from three sources to estimate herd numbers and demographic categories at each dairy: Regional Water Quality Control Board (RWQCB) permits, San Joaquin Valley Air Pollution Control District (SJVAPCD) permits, and individual facility documentation. The RWQCB (water board) permits are required for dairies that existed in October 2007 (California Regional Water Quality Control Board, 2013), and we used a collection of permit lists from 2014–2018 to determine the number of lactating cows. Some dairies in the Central Valley that are either new or expanded since 2007 have inaccurate or incomplete data, so we determined the number of lactating animals from the SJVAQPCD (air pollution district) and reading

[17] Marklein, Alison R., Deanne Meyer, Marc L. Fischer, Seongeun Jeong, Talha Rafiq, Michelle Carr, and Francesca M. Hopkins. "Facility-scale inventory of dairy methane emissions in California: implications for mitigation." *Earth System Science Data* 13, no. 3 (2021): 1151-1166.

> individual facility documentation. The SJVAPCD (air pollution district) permits include the maximum number of cattle in each class at a given facility in 2011, rather than the number of animals, and these dairies may have expanded since then. These data represent our best estimates, but they represent specific points in time that are not consistent between data sources.[18]

The work of the UC Researchers is an example of careful and cautious employment of administrative data. Note that this involved an assumption that herd size uncertainty could be as high as 20%, whereas CADD staff did not mention any uncertainties in the presentation.

So far, we see that administrative data on herd size is spread across at least four sources and is quirky in multiple ways. There appear to be plenty of opportunities for making the kinds of errors that seemingly make CADD data unreliable – in the specific sense that CARB cannot rely on them to estimate aggregated herd sizes for dairies statewide.

Marklein and Hopkins also say: "It is not currently possible to confidently confirm which dairies are functioning and which are not, since dairy closures are tracked by a variety of agencies, with some lag time, but this information is not accessible or consistent."[19] The CADD flowchart shows that an effort was made to use other data sources to determine closures. And the CADD database itself includes a variable that describes which data were reported by the water boards or other agencies, and how much CADD staff had to estimate.

Finally, it is worth noting that all herd size data currently available is self-report from dairy farmers. An October 2024 report cites specific instances of dairies in Tulare County reporting different herd sizes in the same year to different agencies.[20] As long as herd size data is not required with the force of law and verified, we will have the kinds of uncertainty described here.

Missing and estimated data

The CADD variable that describes which observations were estimated (for those observations labeled as dairy) shows that 93% of the observations were "reported" while 7% were "estimated." The presentation says only that estimation was used when there were no annual reports for farms and herd size was estimated using "other sources." In discussions with staff, the only examples given of "estimated," that is, imputed, data were cases where a dairy went out of business so in subsequent years zeros were imputed. However, the data indicate that the mean number of mature cows per farm over all the years when data was *reported* was 1,297 whereas when *estimated* it was 1,547. In fact, over the 11 years, the largest reported herd size was 10,876 whereas the largest estimated herd size was 12,000[21]. For 13 farms, all 11 years are reported as "estimated" and the estimates are identical for all 11

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[18] Ibid.

[19] Ibid.

[20] Molly Armus, Allison Fabrizio, and Carlin Molander. A Brown Cloud Over the Golden State: How Dairy Digesters Are Driving CAFO Expansion and Environmental Injustice in California. Friends of the Earth. October 2024. https://foe.org/wp-content/uploads/2024/10/BrownCloud-ENGLISH-Final-1.pdf

[21] One possibility is that air resources data, which was relied on in a minority of cases, sometimes showed the maximum number of cows a farm was permitted to have rather than the actual number. Also the flowsheet included in the presentation that showed how data was imputed used data from adjacent years, if it existed; so the larger numbers in imputed rather than observed data are still puzzling.

years (including the farm with 12,000 cows). The process, though seemingly precise, has resulted in the anomalies above.

Duplicated data show other anomalies. CADD staff may have imputed duplicate data without clearly flagging this in the CADD database. In a meeting with CADD staff, we were told that in cases where there wasn't reported data for a given year, staff would duplicate data from other years. This suggests that some duplicated (estimated) data may have been classed as "reported" even if it wasn't reported in the year listed. We checked this in the CADD data. For example, there are 86 facilities that reported identical dairy cattle numbers for all 11 years from 2012 to 2022. Of these, 52 label the data as "reported" for *all* of the 11 years. Similarly, there are 294 facilities that have duplicated data for 7 or more years between 2012 to 2022; of these, between 238 and 267 are classed as "reported" in any given year. CADD staff either duplicated data and labeled it as "reported," or accepted large amounts of duplicated data from the farmers and were not able to ground truth it. Either way, the significant amount of duplicated data makes using CADD for trends questionable, especially since staff have not attempted to quantify the uncertainties involved.

There is also a category CADD describes as "no data."[22] Farms with "no data" are equivalent to 9% of the farms labeled as dairies. However, none of the farms with "no data" are considered dairies by CADD staff because they don't show any milk cows. But if there are no data, how do CADD staff know whether there are or are not milk cows on these farms? The table below shows a) the number of dairy farms in the USDA data, b) the number of CADD farms labeled as dairies, c) CADD farms with "no data," and d) CADD dairies plus farms with no data. Since the trend lines for CADD dairies and farms with no data go in opposite directions, the effect of adding the farms with no data to dairies is to reduce the percent reduction in dairies over time from 31% to 27% in CADD data.[23]

Exhibit 6: A Possible Explanation for The Greater Reduction in Herd Size in CADD Data Compared to USDA Census Data

Year	USDA	CADD	NO DATA	CADD + NO DATA
2012	1,931	1,563	68	1,631
2017	1,653	1,302	68	1,370
2022	1,117	1,074	120	1,194
Percent Change	-42%	-31%	+76%	-27%

At least 35% of the "no data" facilities are dairies – based on having "Dairy" in the name of the facility. So this may explain some part of the discrepancy between CADD and USDA trends. CADD staff believe these to be either very small or dairies that are no longer in business. In data analysis, it is generally

[22] These are cattle farms that are known because they are required to report to the water boards, or air quality district or housed cattle between 2012 – 2022 according to Google Earth. There were 2,070 facilities over the years, of these 1,268 were "labeled as dairies in CADD. There were 118 facilities with "no data," or 9%. For 41 of them the word Dairy occurred in the name of the facility. A CADD staff report is obscure: "The goal of the flowchart is to impute missing (non-reported) herd size data. Values in column "Reported (1) vs. Estimated (2) vs. No Data (3)" are not linked to/driven from the flowchart." (Personal communication.)
[23] It is not clear why the reduction in dairies is much greater for USDA data.

considered good practice to impute missing data, especially if they can be presumed to be missing randomly. In this case, CADD staff could impute to the 41 dairies the average herd size of other dairies in the county, and it would be far more accurate than leaving them out entirely (unless they are certain they are defunct).

The largest category of missing data is clearly beef cattle. The CARB presentation says "CADD does not capture all non-dairy cattle facilities in the State" even though they also say "confined bovine feeding operations" are required to report to the same administrative agencies as dairies.

But this statement does not begin to hint at the extent of missing beef cattle data. We know this by comparing what is in CADD with the USDA five-year census. For example, in 2017 the CADD data show only 70,033 beef cattle while the Federal data show 682,372, a difference of roughly 600,000 and a magnitude of error of ten. From discussions with CADD staff, there is no plan to use the beef cattle data.

Also missing is a reliable indicator of whether the data come from a dairy, from a beef cattle operation, or a farm that has both. There is a variable called "labeled as dairy." It shows that of the 21,305 observations in CADD 14,316 are labeled as dairy. "Labeled as dairy" is defined by CADD as containing at least one milk cow. However, of the CADD observations not labeled as dairy only 589 observations included beef cattle. That leaves 6,400 observations where the herd information is not clearly from a dairy or a cattle facility.

This lack is particularly important in cases where there are no beef cattle reported on a farm, and there are no mature cows, only heifers and calves – in other words, farms that raise juvenile animals. But are they for dairies (in which case the animals' enteric emissions would count as dairy emissions) or are they being raised for beef? There is no way to know. In 2022 there were 288 farms of this indeterminate status.

Methodologically questionable projections into the future

In the staff presentation, the indeterminacies in CADD data are considerably magnified by staff as they extend the 2012–2022 trendline through 2023–2030. This is how staff arrived at a dairy herd size reduction of 22% by 2030.

In some cases it can make sense to predict trends to the future, but to project 8 years on the basis of 11 years of data is to make a lot of assumptions about the accuracy of CADD data which—after working with the CADD data—we regard as unwarranted.[24] Reliance on such projections would require that CARB be fairly certain about the causes and continued effect of the decrease in herd sizes CADD shows. To our knowledge CARB has no hypotheses as to why CADD shows a steeper downward trend than the USDA data do, so there is no corroborating evidence that can be adduced in order to support the projection to 2030.

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[24] Clear Institute researchers speculate that reduction in dairy herds will accelerate after 2022. (Mitloehner, Kebreab, Sumner. Meeting the Call: How California is Pioneering a Pathway to Significant Dairy Sector Methane Reduction. December 2022. https://clear.ucdavis.edu/news/new-report-california-pioneering-pathway-significant-dairy-methane-reduction) If one posited greater awareness on the part of consumers of the impact on GHG emissions of dairies, it might accelerate even faster. But there may be counter trends which could even lead to herd growth as appears to be the case with the increase in beef cattle shown in the USDA census for 2022.

A prediction that could be relied upon for policy making should incorporate variables beyond the trendline itself. For example, one factor we do have information on is the tendency of small dairies to go out of business, and larger ones to increase in size. Do we expect that to just continue at a constant rate, or do we think we might have already shaken out the dairies that are too small to make a living? Or, what effects will drought have? Herd sizes might decrease considerably if farmers choose to switch land use to agrivoltaics or other uses. And, as more digesters are installed, will that lead to larger herds? (See Section C below.) As air or water pollution controls tighten,[25] will they lead to changes in herd size? A recent trend is more beef-on-dairies, how will that affect GHG emissions?[26] A reliable forecast builds a model using all of the factors expected to affect the outcome. CARB has not done this.

C. The analysis of whether digesters increase herd size was flawed conceptually and methodologically.

CARB sought to answer the question of whether there was a causal link between having a digester and increases in herd size. However, CARB's problem statement was erroneous, although understandable. The issue of increased herd size has come up in the context of the lucrative avoided emissions credits that dairies are eligible for through the Low Carbon Fuel Standard. So the real issue is whether dairies profiting handsomely from LCFS credits (or perhaps others which have federal credits and biomethane contracts) are expanding herd size in order to capitalize on these income sources. That is, the analysis should focus on dairies with digesters that profit from capturing methane. A good starting place would be the 58 California dairies that get avoided emissions credits from LCFS.[27]

Beyond not choosing the right group to analyze, we find the CARB presentation methodologically naïve. Imagine an experiment in which some dairies were randomly assigned to have a digester and other were not. If that were the case, the statistical analysis that CARB staff employed would have been appropriate.

However, just stating the proposition makes it clear random assignment could never happen. That means that some dairies *choose* to get a digester and sign up for LCFS credits. There is thus likely a "selection bias" as to who signs up. It might be bigger farms, say, but it is likely to be one or more traits of owners that are not observable: ambition, or feeling a responsibility to be sustainable for the climate, or seeing their neighbors profit, for example. In cases like this how do we make a valid comparison between the digester group and some other group of dairies we want to use as a "control" group?

Econometricians have frequently been confronted with this issue: treatment and control groups cannot be assigned randomly. All that is available is observed differences. So how can one infer causality? There are a number of strategies that have been developed over the years.[28] None of them provides the

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[25] For example, this year the EPA lowered the annual standard for particulate matter smaller than 2.5 microns (PM2.5) from 12 to 9 micrograms per cubic meter (µg/m^3) of air. It is unlikely most central valley counties can meet these standards now. https://civileats.com/2024/03/05/california-farm-counties-are-not-even-close-to-meeting-the-epas-new-clean-air-quality-standard/

[26] Beef semen is used to impregnate dairy cows affecting the value of the dairy cows. https://californiadairymagazine.com/2023/08/29/beef-on-dairy-brings-new-value-to-the-marketplace/

[27]See the list of dairies in LCFS at: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx c.

[28] Some of these methods are: Difference in difference regression, propensity score selection of control group, regression-discontinuity, and instrumental variable analysis. There are many sources; here are a couple: Igelström,

same kind of certainty that a randomized experiment does, but they are far more likely to be valid than the CARB analysis, which only attempted to hold constant herd size.

The analysis in this case is more difficult because there are so few variables known about the dairies. One way of getting comparable farms is to limit candidates to counties that have one or more farms with a digester. It is likely that there is some peer effect on the choice to implement a digester and county would be a proxy for it. Another way of creating a more comparable control group is to use GPS coordinates to map proximity to the biomethane production centers used by dairies. Dairies without this proximity are not likely to face the same kinds of motivational intangibles in whether or not to install a digester. The most important aspect of the CADD data, though, is that it is longitudinal, so it is possible to calculate how much or little herd sizes are going up in the five years prior to the digester era and match farms with digesters to farms that have a similar trajectory *before* the digesters were installed. *We don't know if CARB employs an econometrician with skills in conducting observational causal analysis, if not it would be appropriate to contract with a university researcher.*

A third defect in the CARB presentation was in not simply admitting what the environmental justice advocates have been saying all along: According the CARB, herd sizes in dairies with digesters increased an average of 1.3% a year. However, the analysis could have been much more helpful. Dairies in the CADD data were operating digesters from 1 to 9 years. It would be instructive to produce a table of the herd size changes for *each* of the dairies with digesters along with how many years they were in operation. That is, even if a causal analysis is not possible, CARB could let Central Valley residents check their perceptions by showing them the data for the digesters they are living with.

We have created one version of such a table, Exhibit 7 below. Instead of looking at annual rates of increase as in the CARB presentation we show the actual herd sizes in the year the digester began operation, and in the last year of operation (2022 in most cases). We did not include digesters that started before 2012 because the baseline was missing. The data are shown in Appendix 4. Both "mature cows" (lactating and dry) and "all cattle" on the farm (mature cows, heifers, calves, beef cattle combined) are shown. There are a total of 98 dairies with digesters included. The table below summarizes the mean amount of herd change by years the digester was in operation. Of the 98 dairies, 24 were only in operation during 2022 so there was no herd size change possible (CADD data are an average for the year). Another 37 dairies were in operation for one year and show a small negative change for both mature cows and all cattle. The only large herd size is for the two dairies that operated a digester for eight years. Herd size changes for other years of operation were small or negative.

All of the weaknesses of the CADD data we have discussed, including the considerable use of herd size counts that duplicate from year to year, could affect these results. But in these data we find no consistent pattern of increased herd size driven by years of having a digester.

Erik, Peter Craig, Jim Lewsey, John Lynch, Anna Pearce, and Srinivasa Vittal Katikireddi. "Causal inference and effect estimation using observational data." *J Epidemiol Community Health* 76, no. 11 (2022): 960-966. Stuart, Elizabeth A., Donald B. Rubin, and J. Osborne. "Matching methods for causal inference: Designing observational studies." *Harvard University Department of Statistics mimeo* (2004).

Exhibit 7: Mean Herd Size by Years of Digester Operation for 98 Dairies

Years of Operation	Number of Dairies	Mean Mature Cow Change	Mean All Cattle Change
0	24	0.00	0.00
1	37	-7.03	-45.14
2	11	52.18	94.36
3	10	87.60	295.50
4	6	11.83	-201.83
5	2	-214.50	-2,915.50
6	2	-15.00	-38.50
7	1	0.00	-8.00
8	2	1,942.00	3,747.00
9	3	-78.67	241.33

Finally, as suggested above, we applied the same analysis specifically to dairies in the LCFS program, those being paid well enough for the methane they collect that they might increase herd size to increase income. The public database[29] for the LCFS contains 1,837 "pathways;" 963 are labeled "retired pathway." Of the 870 active pathways 90 have the feedstock "dairy manure." However, in only 58 are the dairies located in California. In the other 32 cases the dairies are in midwestern states, but they transport their methane to a processor in California.

CADD staff did not include digesters participating in the LCFS in their list of digesters, perhaps assuming all had received assistance from the Dairy Digester Research and Development Program (DDRDP), whose digesters were included. However, while 42 of the 58 California LCFS digesters were funded by the DDRDP, the other 16 were not. We compared the list of 58 California dairies with digesters in the LCFS program with the list of digesters linked to CADD data by the CADDID, using dairy name as the match variable. We found 45 dairies in the LCFS program whose herd sizes are part of CADD data. In Appendix 5 we show the 45 dairies with their names and city and with the amount of herd size change associated with their time using digesters. This is the same herd size data as in Appendix 4 but instead of 99 dairies there are only the 45 that were in the LCFS and the dairies are identified. Overall, in 17 of the 45 dairies there was an increase in mature cow herd size; in 7 there was no herd size change; and 20 had a reduction in herd size. The largest increase was 490 mature cows. In Exhibit 8, we show information about herd size change in relationship to years of operation. The longer a digester is in operation, the more we would expect to see larger herd sizes based on generous LCFS earnings leading to purchasing more cows. That pattern is not evident here.

[29] Accessed in December 2023: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx

Exhibit 8: Mean Herd Size by Years of Digester Operation for 45 LCFS Dairies

Years of Operation	Number of Dairies	Mean Mature Cow Change	Mean All Cattle Change
0	2	0.00	0.00
1	25	6.16	-49.56
2	7	72.43	64.14
3	4	51.75	43.00
4	1	-84.00	-125.00
5	2	-214.50	-2915.50
6	1	-30.00	-77.00
7	1	0.00	-8.00
9	2	-7.50	-84.00

D. A better approach

In short, the data described in the CARB staff presentation is not fit to purpose.

Given all the issues we have raised, we believe it makes far more sense for CARB to simply require all dairy and livestock farms to report the necessary herd size and other emissions-relevant data on an annual basis through a survey. The agency clearly has the authority to do this. Satellite and aerial data could be an important way to verify survey data.[30]

We do not, however, believe that the CADD exercise has been wasted effort. This is the first public disclosure of dairy farm owners, locations, and herd sizes, and we applaud and thank CARB for making this information available to the public and CDFA. And surely there are many other uses for CADD data – similar to the question of whether herd size increases are associated with digesters. We trust CARB will find other important uses for CADD as the essential work to reduce methane and other pollutant releases from dairies continues.

Finally, we want to suggest an alternative or supplemental approach to the usual comment/review procedure CARB employs. CARB should create a scientific panel specifically to peer-review all the CARB staff methane measurement efforts and suggest ways of making them more accurate and useful, particularly for regulation.

E. Expanding the vision

The lives of Central Valley residents are injured by air and water pollution, a significant part of which is contributed by dairies and other livestock. According to testimony of residents, their lives changed in the period between 1990 and 2012, when the dairy industry expanded with the addition of many CAFOs. The most direct way to deal with dairy threats to quality of life is to reduce the number of dairies.

[30] Professor Francesca Hopkins is about to publish a paper on this strategy (personal communication)

1. The Netherlands has recently begun a program of buying farms and fallowing the land. Over 750 farmers have already signed up, with a total outlay of $1.5 billion expected.[31]

2. Part of the problem with digesters is that many use diesel generators. And especially in the hub and spoke model, diesel truck pollution is intense. Both regulation and incentives are needed to get farms to use fuel cells for their digesters and to electrify trucks. The second 15-day amendments to LCFS regulations fail in this regard. (And while we are at it, we need to get HFCs, also short-lived climate pollutants, out of dairy cold storage!)

3. Transforming the San Joaquin Valley will be expensive. The solution could be the one adopted recently by Denmark: Tax greenhouse gas emissions from agriculture, including livestock, fertilizer, forestry, and the disturbance of carbon-rich agricultural soils.[32] In Denmark, the tax will be roughly $18 per MT CO2, or not far from California's Cap and Trade price. This will cost livestock owners about $85 per animal each year. There is a 60% discount for the most sustainable farms, which ultimately may pay very little. The proceeds of the tax go into incentives to support agriculture's green transition.

4. The saddest moment in CARB's August 22 workshop was when a dairy farmer described the nitrate pollution of the ground water in the county—the result of 100 years of unsustainable farming—and then praised himself and other dairy owners for providing several drinking water stations around the county. The problems of the Central Valley are interdependent. The Water Boards, the air districts, the CDFA, and CARB know what to do and have the authority to do it. It is time to cooperate to bring clean air and water to this still-lovely part of California.

PLEASE SEE APPENDICES BELOW.

[31] https://www.euronews.com/green/2023/11/30/dutch-farmers-could-be-paid-to-close-their-livestock-farms-under-new-scheme
[32] https://www.carbonbrief.org/qa-how-denmark-plans-to-tax-agriculture-emissions-to-meet-climate-goals/

APPENDIX 1: Comparison of CADD, Vista and USDA *Farms* for 2017

County	USDA Farms	Vista Farms	CADD Farms	Fraction CADD is of USDA
Butte	10	3	2	0.20
Colusa	4	1	0	0.00
Del Norte	7	8	7	1.00
Fresno	65	81	62	0.95
Glenn	28	36	24	0.86
Humboldt	96	63	54	0.56
Imperial	2	16	2	1.00
Kern	41	53	45	1.10
Kings	101	153	104	1.03
Lassen	8	2	0	0.00
Los Angeles	1	1	1	1.00
Madera	34	46	34	1.00
Marin	31	26	23	0.74
Mendocino	13	5	2	0.15
Merced	202	289	215	1.06
Modoc	2	1	0	0.00
Monterey	7	1	1	0.14
Placer	25	2	1	0.04
Riverside	36	33	27	0.75
Sacramento	34	36	29	0.85
San Bernardino	40	76	53	1.33
San Diego	9	4	3	0.33
San Joaquin	97	129	99	1.02
San Luis Obispo	16	1	1	0.06
San Mateo	4	1	0	0.00
Santa Barbara	3	1	1	0.33
Siskiyou	15	3	3	0.20
Solano	8	2	2	0.25
Sonoma	125	68	64	0.51
Stanislaus	190	255	183	0.96
Sutter	4	1	0	0.00
Tehama	35	12	8	0.23
Tulare	235	312	247	1.05
Yolo	4	2	2	0.50
Yuba	6	4	3	0.50
Total	1,538	1,727	1,302	0.85

Green font indicates fairly close agreement of sources, up to 10% difference.

APPENDIX 2: Comparison of CADD, Vista and USDA Census *Herd Size* Data for 2017

County	USDA Cows	Vista Cows	CADD Cows	Fraction CADD is of Vista	Fraction CADD is of USDA
Butte	427	468	443	0.95	1.04
Colusa	80	80	0	0.00	0.00
Del Norte	6,452	6,448	4,025	0.62	0.62
Fresno	102,796	102,790	106,484	1.04	1.04
Glenn	15,533	15,534	17,401	1.12	1.12
Humboldt	23,894	23,877	15,240	0.64	0.64
Imperial	0	0	6,517	NA	NA
Kern	116,605	129,794	150,836	1.16	1.29
Kings	173,404	173,409	171,897	0.99	0.99
Lassen	22	22	0	0.00	0.00
Los Angeles	0	0	4,600	NA	NA
Madera	66,038	67,661	77,493	1.15	1.17
Marin	10,895	10,894	6,938	0.64	0.64
Mendocino	1,182	1,180	980	0.83	0.83
Merced	272,534	272,545	256,170	0.94	0.94
Modoc	0	0	0	NA	NA
Monterey	1,445	1,445	831	0.58	0.58
Placer	946	946	660	0.70	0.70
Riverside	38,033	38,049	42,562	1.12	1.12
Sacramento	16,027	16,026	14,151	0.88	0.88
San Bernardino	52,554	52,592	49,390	0.94	0.94
San Diego	4,330	4,328	1,990	0.46	0.46
San Joaquin	106,375	106,366	93,763	0.88	0.88
San Luis Obispo	256	256	243	0.95	0.95
San Mateo	10	10	0	0.00	0.00
Santa Barbara	0	1,600	1,795	1.12	NA
Siskiyou	1,193	1,194	725	0.61	0.61
Solano	22	611	4,144	6.78	188.36
Sonoma	33,059	33,048	24,025	0.73	0.73
Stanislaus	183,496	183,464	166,189	0.91	0.91
Sutter	5	5	0	0.00	0.00
Tehama	3,249	3,253	3,009	0.92	0.93
Tulare	500,402	500,395	483,225	0.97	0.97
Yolo	0	105	2,122	20.21	NA
Yuba	0	1,417	3,177	2.24	NA
Total	1,731,264	1,749,812	1,711,025	NA	NA

Purple font indicates fairly close agreement (roughly 10% or less difference)

APPENDIX 3: Sub-County Comparisons of USDA and CADD Data in Four Counties in 2022[33]

Kern County dairy farms comparison in 2022

Mature Cow Herd Size	USDA: Dairies	CADD: Dairies
1-9	5	-
10-19	3	-
20-49	1	-
50-99	-	-
100-199	-	-
200-499	-	1
500 or more	36	43
Total Farms	45	44
Total Cows	129,250	153,319

Merced County dairy farms comparison in 2022

Mature Cow Herd Size	USDA: Dairies	CADD: Dairies
1-9	8	-
10-19	2	-
20-49	1	1
50-99	-	1
100-199	1	2
200-499	6	28
500 or more	142	150
Total Farms	160	182
Total Cows	288,973	251,873

Humboldt County dairy farms comparison in 2022

Mature Cow Herd Size	USDA: Dairies	CADD: Dairies
1-9	2	-
10-19	2	-
20-49	-	-
50-99	3	7
100-199	5	9
200-499	11	22
500 or more	2	6
Total Farms	25	44
Total Cows	6,904	13,661

Stanislaus County dairy farms comparison in 2022

Mature Cow Herd Size	USDA: Dairies	CADD: Dairies
1-9	11	-
10-19	-	-
20-49	2	-
50-99	-	1
100-199	-	1
200-499	11	30
500 or more	101	120
Total Farms	125	152
Total Cows	153,912	155,243

[33] USDA data from California Census with Farms by County by Size, Table 11.

APPENDIX 4: Change in Herd Size for Farms with Digesters, Start-Up Year to Last Available Data

CADDID	Digester Start Year	Mature Cows1	All Cattle1	Digester Last Year	Mature Cows2	All Cattle2	Mature Cow Change	All Cattle Change
10050	2014	7,565	11,620	2022	9,850	16,350	2,285	4,730
11001	2014	1,080	2,005	2022	2,679	4,769	1,599	2,764
11024	2020	1,596	3,388	2022	2,086	3,843	490	455
11169	2013	2,050	4,050	2016	2,350	4,475	300	425
10438	2018	2,675	4,570	2022	2,941	5,241	266	671
10222	2021	6,623	11,068	2022	6,873	11,280	250	212
11038	2019	4,162	6,584	2022	4,388	6,809	226	225
10329	2021	6,385	10,540	2022	6,560	10,825	175	285
11012	2021	2,386	4,583	2022	2,538	4,765	152	182
10774	2021	4,300	4,500	2022	4,450	4,950	150	450
10090	2019	5,693	10,938	2022	5,834	11,218	141	280
11021	2020	4,845	8,316	2022	4,962	8,525	117	209
10771	2019	2,906	5,816	2022	3,020	5,964	114	148
10886	2019	2,790	4,340	2022	2,900	4,450	110	110
11020	2018	5,240	8,402	2022	5,325	6,880	85	-1,522
10506	2019	4,603	9,137	2022	4,684	9,126	81	-11
10070	2019	5,086	7,279	2022	5,137	9,230	51	1,951
10731	2021	3,950	7,830	2022	4,000	7,950	50	120
10591	2020	7,262	14,176	2022	7,309	14,249	47	73
10692	2020	4,552	4,552	2022	4,594	4,594	42	42
11045	2020	2,810	5,882	2022	2,845	5,947	35	65
10056	2021	3,520	7,290	2022	3,545	7,390	25	100
11016	2021	3,703	5,934	2022	3,726	5,990	23	56
10236	2021	4,005	5,784	2022	4,025	5,787	20	3
10657	2020	3,220	5,763	2022	3,240	5,670	20	-93
11544	2021	2,996	4,971	2022	3,010	4,980	14	9
10899	2021	2,034	3,342	2022	2,046	3,371	12	29
10900	2013	990	1,950	2022	1,000	2,000	10	50
10984	2018	4,222	9,051	2022	4,232	8,966	10	-85
10939	2021	5,996	8,160	2022	6,002	8,168	6	8
11673	2021	3,605	7,655	2022	3,610	7,185	5	-470
10921	2021	5,433	7,177	2022	5,435	7,206	2	29
10053	2022	3,540	8,320	2022	3,540	8,320	0	0

CADDID	Digester Start Year	Mature Cows1	All Cattle1	Digester Last Year	Mature Cows2	All Cattle2	Mature Cow Change	All Cattle Change
10069	2021	7,650	16,450	2022	7,650	16,450	0	0
10142	2022	1,225	2,305	2022	1,225	2,305	0	0
10152	2022	6,989	10,498	2022	6,989	10,498	0	0
10252	2021	2,330	6,430	2022	2,330	6,430	0	0
10331	2022	3,865	5,113	2022	3,865	5,113	0	0
10340	2022	4,507	7,945	2022	4,507	7,945	0	0
10400	2022	3,750	5,250	2022	3,750	5,250	0	0
10406	2022	4,993	8,268	2022	4,993	8,268	0	0
10514	2022	4,534	4,660	2022	4,534	4,660	0	0
10763	2021	3,433	5,616	2022	3,433	5,616	0	0
10822	2022	5,950	9,015	2022	5,950	9,015	0	0
10891	2015	675	1,228	2022	675	1,220	0	-8
10925	2022	2,618	4,766	2022	2,618	4,766	0	0
10948	2022	1,742	3,455	2022	1,742	3,455	0	0
10975	2018	2,750	3,200	2022	2,750	3,350	0	150
10985	2021	6,500	6,500	2022	6,500	6,500	0	0
11013	2022	3,456	5,570	2022	3,456	5,570	0	0
11025	2022	1,740	3,090	2022	1,740	3,090	0	0
11026	2022	2,914	5,929	2022	2,914	5,929	0	0
11180	2022	3,565	5,990	2022	3,565	5,990	0	0
11188	2022	2,530	3,742	2022	2,530	3,742	0	0
11272	2020	3,330	5,676	2022	3,330	5,676	0	0
11275	2020	1,400	2,450	2022	1,400	2,180	0	-270
11523	2022	5,490	9,383	2022	5,490	9,383	0	0
11530	2022	3,335	5,535	2022	3,335	5,535	0	0
11538	2022	2,869	4,099	2022	2,869	4,099	0	0
11662	2021	2,885	7,077	2022	2,885	7,008	0	-69
11665	2022	4,200	7,300	2022	4,200	7,300	0	0
11666	2022	2,662	5,279	2022	2,662	5,279	0	0
11667	2022	3,570	5,945	2022	3,570	5,945	0	0
11670	2016	12,000	19,508	2022	12,000	19,508	0	0
11671	2022	1,750	1,948	2022	1,750	1,948	0	0
11672	2022	6,450	8,606	2022	6,450	8,606	0	0
11680	2021	5,725	9,050	2022	5,725	9,050	0	0
10746	2021	6,190	11,060	2022	6,189	11,027	-1	-33
10386	2021	2,767	5,607	2022	2,763	5,618	-4	11
10889	2021	2,185	3,907	2022	2,181	3,912	-4	5

CADDID	Digester Start Year	Mature Cows1	All Cattle1	Digester Last Year	Mature Cows2	All Cattle 2	Mature Cow Change	All Cattle Change
10250	2021	2,071	5,109	2022	2,066	5,116	-5	7
10058	2021	1,422	1,498	2022	1,415	1,477	-7	-21
10165	2021	5,659	5,659	2022	5,651	5,651	-8	-8
10542	2021	5,125	10,945	2022	5,115	10,975	-10	30
10981	2021	3,604	6,075	2022	3,594	6,070	-10	-5
10800	2019	1,402	1,471	2022	1,388	1,499	-14	28
10977	2021	3,165	3,165	2022	3,151	3,151	-14	-14
10879	2021	1,215	1,215	2022	1,200	1,200	-15	-15
10377	2021	3,293	5,956	2022	3,277	5,942	-16	-14
10747	2021	5,332	10,589	2022	5,313	10,485	-19	-104
11262	2021	3,600	7,020	2022	3,581	7,005	-19	-15
11184	2021	2,425	3,275	2022	2,405	3,275	-20	0
11522	2013	1,400	1,450	2016	1,380	1,410	-20	-40
10528	2013	1,235	2,228	2022	1,210	2,010	-25	-218
10757	2020	3,975	5,110	2022	3,950	5,070	-25	-40
10909	2016	5,214	9,299	2022	5,184	9,222	-30	-77
10098	2021	2,875	5,676	2022	2,835	5,648	-40	-28
10767	2020	3,850	6,550	2022	3,800	7,200	-50	650
10890	2012	310	605	2016	226	480	-84	-125
11023	2017	5,051	10,606	2022	4,950	5,476	-101	-5,130
10674	2021	4,050	7,100	2022	3,948	6,920	-102	-180
11015	2020	3,757	6,738	2022	3,655	6,685	-102	-53
11040	2019	3,288	6,035	2022	3,175	5,874	-113	-161
11022	2018	5,956	10,420	2022	5,750	10,120	-206	-300
10970	2013	8,886	13,008	2022	8,665	13,900	-221	892
10710	2017	3,318	5,618	2022	2,990	4,917	-328	-701
11042	2021	6,450	11,250	2022	6,050	9,550	-400	-1,700
10740	2021	3,950	6,830	2022	3,500	6,300	-450	-530

APPENDIX 5: Change in Mature Cow and All Cattle Herd Size for 45 Dairies with Digesters Enrolled in the Low Carbon Fuel Standard: Start-up Year to Last Available Data[34]

CADDID	Dairy Name	City	Mature Cow Change	All Cattle Change
11024	Little Rock Dairy	Tipton	490	455
10222	Double J Dairy	Visalia	250	212
11038	Cornerstone Dairy	Tipton	226	225
11012	Mellema Dairy	Visalia	152	182
10774	Scheenstra Dairy	Tipton	150	450
10771	Legacy Ranches #2	Pixley	114	148
10731	Rancho Teresita Dairy	Tulare	50	120
10591	Maple Dairy	Bakersfield	47	73
10692	Trilogy Dairy	Bakersfield	42	42
11045	4K Dairy Farm Partnership	Pixley	35	65
10056	Aukeman Farms	Tulare	25	100
11016	Bos Farms LP	Tulare	23	56
10657	Moonlight Dairy	Visalia	20	-93
11544	Red Rock Dairy	Merced	14	9
10900	Van Warmerdam Dairy	Galt	10	50
10939	Wreden Ranch Dairy	Hanford	6	8
11673	MINERAL KING DAIRY	VISALIA	5	-470
10921	Western Sky Dairy	Bakersfield	2	29
11662	Decade Dairy	TULARE	0	-69
10891	Van Steyn Dairy	Elk Grove	0	-8
10763	McMoo Farms Dairy	Bakersfield	0	0
11530	Vista Verde Dairy	Chowchilla	0	0
10252	El Monte Dairy	Tipton	0	0
10985	Dixie Creek Ranch	Hanford	0	0
11523	Double Diamond Dairy	El Nido	0	0
10746	River Ranch Dairy	Hanford	-1	-33
10386	Hollandia Farms Dairy	Hanford	-4	11
10250	Valadao Dairy	Hanford	-5	7
10058	Jacobus DeGroot Dairy #2	Visalia	-7	-21
10165	Cloverdale Dairy	Hanford	-8	-8
10981	Newhouse Dairy	Bakersfield	-10	-5
10542	Lone Oak Farms Dairy #1	Hanford	-10	30
10747	Riverbend Dairy	Tulare	-19	-104
11262	Vander Woude Dairy	Merced	-19	-15
11522	New Hope Dairy, LLC	Galt	-20	-40
10528	Bidart Dairy No. 3	Bakersfield	-25	-218
10757	B. V. Dairy	Bakersfield	-25	-40
10909	Open Sky Ranch Dairy	Riverdale	-30	-77
10098	Rancho Sierra Vista Dairy	Visalia	-40	-28
10890	Van Steyn Dairy	Lakeside	-84	-125
11023	Coronado Dairy Farms	Tipton	-101	-5130
11015	Hamstra Dairy Complex	Tulare	-102	-53
11040	Riverview Dairy	Pixley	-113	-161
10710	Philip Verwey Dairy, Inc.	Madera	-328	-701
11042	Horizon Jerseys Dairy	Tipton	-400	-1700

[34] Sorted on Mature Cow Change. All Cattle = mature cows, heifers, calves and beef cattle