Comments on
California Communities Environmental Health Screening Tool (CalEnviroScreen): Proposed Method & Indicators
July 30, 2012 (External Review Draft)[1]

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[1] The preparation of these comments was supported by the California Chamber of Commerce. The analysis and opinions expressed herein belong solely to the author.

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QUALIFICATIONS, EXPERIENCE, AND SPONSORSHIP

Though I currently reside in Virginia, I was born in Los Angeles and raised entirely in Torrance. My wife hails from the Westchester section of the City of Los Angeles. Our parents moved to California in 1945 and 1949, respectively, to take advantage of the wealth of economic opportunities that California offered but which were not available at that time in Texas and Wisconsin. We have many family members who never left the State, and likely never will. My connection to California thus remains as strong as ever. I have a personal as well as professional interest in ensuring that Cal/EPA's final environmental justice screening tool serves its intended purposes well and for the benefit of the people it is supposed to help.

Education

I earned my bachelor's and master's degrees in agricultural economics at the University of California at Davis (1979, 1980), and a master's in public policy (1982) from the John F. Kennedy School of Government (recently renamed as Harvard Kennedy School). Subsequently I earned a doctorate from Harvard University (1989).

While an undergraduate at UC Davis, I worked as a research assistant in the Division of Environmental Studies and co-authored reports and papers on the effects of local growth control regulations on housing prices. My master's thesis at Davis was an econometric analysis of how results were sensitive to information quality and the geographic unit of analysis used to characterize community characteristics. At the Kennedy School, my master's thesis was an evaluation of how federally insured mortgages inflated the prices of FHA-guaranteed mortgages. My doctoral dissertation was an evaluation of deposit-refund systems for the management of hazardous waste, with a specific application to used lubricating oil.

Relevant Technical Experience

From 1988-98, I served as a civil service economist in the Office of Information and Regulatory Affairs at the U.S. Office of Management and Budget (OMB). This position required both a high degree of technical competence and an appreciation of the President's role in supervising Executive branch regulatory agencies. I was a stickler of analytic quality in human health risk assessment and regulatory impact analysis, and won several awards for the quality of my work.

During this period, health risk assessment suffered from a dearth of exposure data and thus relied on hazard estimates based usually on toxicological studies. To the extent that exposure data were used, they were based on convenience samples that could not be legitimately extrapolated to any known population or subpopulation.

For this reason, I led an effort at OMB to encourage the generation and use of human exposure data obtained from statistically valid, representative samples. I shepherded through OMB's Paperwork Reduction Act clearance process the National Human Exposure Assessment Survey (NHEXAS), USEPA's first effort to obtain exposure data from

representative samples of U.S. residents. Dozens of peer-reviewed papers have been published utilizing these data sets.

From 1998-2001 I was a visiting professor of public policy at Washington University in St. Louis and a researcher at the university's Wiedenbaum Center. Since 2001, I have managed multiple nonprofit organizations and performed consulting projects for a variety of clients.

Professional Memberships and Service

I am a member of the American Economic Association, the Society for Benefit Cost Analysis, the Society for Risk Analysis, and the American Association of Wine Economists.

In 1998 and 2000, I was elected Treasurer of the Society for Risk Analysis, and served on SRA's Executive Committee for five years. In 2003, I was given the Society's Outstanding Service Award. In 2009 and 2011, I was elected Secretary/Treasurer of the Society for Benefit Cost Analysis, a new professional society established with significant financial support from the MacArthur Foundation.

I am a regular peer reviewer for multiple scholarly journals, including *Environmental Health Perspectives* and *Risk Analysis*.

My full CV is available at http://www.rbbelzer.com/curriculum-vitae.html.

Scope of Review

This comment concerns the July 30, 2012 Draft Report on the proposed EJ screening tool (hereinafter referred to as the "Draft Report").[2] Related supporting documents are mentioned, including OEHHA's 2010 report titled *Cumulative Impacts: Building a Scientific Foundation* (hereinafter referred to as the "CI Report"), and a pair of articles published by OEHHA staff.[3] However, a comprehensive review of these supporting documents was beyond the scope of my charge.

Sponsorship

The preparation of these comments was supported by the California Chamber of Commerce. The analyses are my own, and any opinions and judgments expressed herein ay not necessarily reflect those of the Chamber.

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[2] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b)

[3] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2010), Alexeeff, et al. (2012), August, et al. (2012).

EXECUTIVE SUMMARY

Part 1: The Economics of Ameliorating Environmental Inequality

Part 1 of this paper, beginning on page 15, discusses the economics of identifying and ameliorating environmental inequality in greater detail. Special attention is devoted to the predictably adverse effects of using the proposed EJ screening tool in ways that directly or indirectly harm the very people it is supposed to help. The points made in Part 1 are summarized below.

OEHHA's proposed EJ screening tool has taken a long time to develop, and thus it should be no surprise that many interested parties have grown impatient. One of the reasons it has taken so long is the process through which the screening tool has been developed has lacked an appreciation for the economics of environmental inequality. The economic paradigm is commonly misunderstood, especially in the environmental health community, as a fixation on money. This is both unfair and inaccurate. The economic paradigm is about the inevitability of tradeoffs, the often-ignored reality that choices are constrained by limited resources. To acquire any good and useful thing requires us to give up other good and useful things. We are better off if and only if the value of what we gain is greater than the value of what we have to sacrifice to get it, which economists call *opportunity cost*. So far, there is little evidence that Cal/EPA and OEHHA officials, or scholars and advocates in academia, or most interest group stakeholders, have taken opportunity costs seriously. If it is not remedied soon, the consequences of this persistent denial could be devastating to the very communities that environmental justice is supposed to benefit.

Not all geographically defined environmental inequality violates principles of environmental justice.

Geographical environmental inequality has many potential causes, but not all of them violate the State's definition of environmental justice, which calls for "fair treatment" of all. Geographic inequalities that are borne voluntarily, or are inherent features of California's diverse geography, probably do not qualify as unfair. OEHHA and Cal/EPA should focus their attention on environmental inequalities that some communities bear involuntarily. For that reason, OEHHA's EJ screening tool ought to be designed to accurately distinguish between voluntarily and involuntarily borne environmental inequalities. Similarly, any administrative and regulatory interventions intended to remedy involuntarily borne environmental inequalities should be selected that target the underlying cause, not just observable symptoms and not factors over which the State has neither control nor influence.

Geography is not the only means why which people could be organized such that profound environmental inequalities existed. To take an obvious but hypothetical example, one group of California residents could be uniformly and unambiguously subjected to overt discrimination, but if they were spatially distributed at random no geographical system of identification would detect them.

The proposed EJ screening tool cannot distinguish between voluntarily- and involuntarily-borne environmental inequalities.

Whereas the proposed tool appears to be sensitive enough to correctly assign most bona fide EJ communities into a small number of broad categories, there are numerous reasons why it cannot accurately make valid and reliable assignments across multiple categories, much less yield valid rankings for over 1,600 Zip Codes. Involuntarily borne environmental inequities are closest to what the State's definition of environmental justice seeks to identify, but the proposed screening tool lacks any capacity to distinguish voluntarily from involuntarily borne environmental inequality.

OEHHA committed to designing a *screening* tool, but it has proposed instead a fatally flawed *regulatory support* tool.

These limitations are serious enough for a true screening tool, but it would be possible for OEHHA and Cal/EPA to overcome them if they limited the application of the screening tool to its ostensible purpose: screening communities to determine which ones deserve more intensive scrutiny to ascertain whether they experience actionable environmental inequalities. Unfortunately, there is ample evidence in the draft report and supporting documents indicating that OEHHA actually intends its "screening tool" to be misused for regulatory decision-making. As a decision tool, the proposed EJ screening tool is fatally flawed and not reconcilable with even the barest minimum of scientific standards. Some proposed pollution exposure indicators do not measure exposure to pollution; most proposed indicators of public health effects from pollution do not measure public health effects from pollution; and none of the proposed indicators of environmental effects from pollution measure environmental effects from pollution. These defects are compounded by the multiplicative weight given to factors that poorly correlate with socioeconomic markers of community disadvantage.

If Cal/EPA misuses the proposed EJ screening tool as a regulatory support tool, it is likely to make the intended beneficiaries worse off.

If OEHHA's proposed EJ screening tool were misused as a regulatory decision-making tool, there is a significant risk that it would unintentionally make bona fide EJ communities worse off. To understand why requires appreciating the *opportunity cost* of ameliorating environmental inequality. The opportunity cost of obtaining and enjoying any good and useful thing—in this case, less environmental inequality—is the value of other good and useful things that must be sacrificed in order to obtain it. Individuals, households, and governments alike all face budget constraints that deny them any way to avoid opportunity costs. Moreover, establishing environmental justice as a positive legal right may succeed in hiding opportunity costs, but it would not make opportunity costs go away.

Whatever level of equality California officials decide to achieve in the allocation of the "development, adoption, implementation, and enforcement of environmental laws, regulations, and policies," the best way to do so is by minimizing opportunity cost. Sacrificing any more than that wastes scarce resources and makes all of California—especially its most disadvantaged residents—worse off.

When regulation is used to deliver additional environmental protection to EJ communities, it is EJ communities themselves that often bear most of the opportunity cost. Competitive markets shift regulatory costs to customers (via higher prices), suppliers (via lower payments for inputs to production), labor (via lower wages and salaries), governments (via lower tax payments due to fewer sales, less income, or both), and capital (via lower returns on investment). How much regulatory cost is shifted, and where, depends on the specific market circumstances of each regulated entity.

Cal/EPA were to single out communities with high composite EJ screening tool scores for additional regulatory or permitting requirements, future investment in these communities will be discouraged and both the number of residents employed and their wages will decline. These outcomes make presumptive EJ communities unambiguously worse off. In California, there may be no greater environmental catastrophe that can befall a community than high, sustained, and rising unemployment, and a permanently distressed investment climate. These predictable injuries, as bad as they are, would be supplemented by the insult that many investments would be shifted to California communities exempt from additional regulatory or permitting burdens because they have low composite EJ screening tool scores.

If Cal/EPA is determined to improperly use the proposed EJ screening tool as a regulatory support tool, it is crucial that the Agency do so in ways that reduce rather than increase regulatory and permitting burdens on EJ communities.

Screening tools should never be used for decision support or decision-making, but if Cal/EPA insists on misusing the EJ screening tool this way, it should use it to creatively relieve communities with high composite scores from overly burdensome regulatory or permitting requirements. If it does so, then investments in these communities would be encouraged and employment could increase. This is the conventional, bipartisan approach to remedying economically distressed communities under the rubric of "enterprise zones." Of course, the benefits of enterprise zones depend on how they are designed and implemented. The usual tools for increasing investment in enterprise zones tend to consist of tax preferences, but regulatory relief could be equally or more effective and have superior targeting efficiency. The benefits to a community of being identified as an *environmental* enterprise zone also would depend on how regulatory relief was designed and implemented. There is no reason why targeted regulatory relief needs to compromise fundamental protections for public health and environmental quality.

To avoid causing these communities further harm, Cal/EPA should take a closer look at the implications of emphasizing so-called *precautionary approaches*, as that term is now defined. People are by nature risk averse, so precaution comes naturally. But precaution is not free; it has its own opportunity costs, which mean that acting in a precautionary manner with respect to *environmental* risk requires being anti-precautionary (that is, "risk loving") with respect to *other* risks, such as rising crime, faltering school performance, deteriorating housing quality, or rampant unemployment and poverty—risks that Californians who reside in wealthier communities do not often experience. There are sound theoretical and empirical reasons for believing that residents of EJ communities may be more precautionary with respect to these risks than they are to environmental health risks.

For that reason, Cal/EPA should be careful to learn about, and fully account for, the revealed preferences of residents of EJ communities—the intended beneficiaries of its plan to reduce environmental inequality—before embarking on any new spending or regulatory programs. It would be very easy for Cal/EPA to secure modest (and perhaps undetectable) reductions in environmental inequality at the opportunity cost of significantly reducing community welfare on other margins that community residents consider more important.

EJ communities are highly vulnerable to the unintended consequences of well-meaning but misguided efforts to reduce environmental inequality.

Evidence of extensive economic deprivation is widespread. Only four of 26 federally defined Metropolitan Statistical Areas (MSAs) in California currently experience economic conditions better than the nation at large, which remains mired in a weak, jobless recovery following the 2007-09 recession. In most of the other 22 MSAs, economic conditions are simply dreadful.

The proposed screening tool includes certain indicators of economic disadvantage and gives them additional weight in EJ scoring by using a multiplicative model. This feature of the proposed model reflects a concerted policy judgment that any fixed level of environmental inequality disproportionately more severe in economically distressed communities. This logic also implies, however, that economically distressed communities will be disproportionately vulnerable to the unintended consequences of governmental actions intended to reduce environmental inequality. For this reason, it is essential that Cal/EPA make an ironclad commitment that, however it implements the results of OEHHA's EJ screening tool, the Agency do so in a way that does no harm, whether directly or indirectly. The economic distress these communities currently experience is so great that adverse economic effects that wealthier California communities might consider minor or even innocuous could spell disaster for them.

Part 2: Conceptual Issues Posed by the Proposed EJ Screening Model

Part 2 of this paper, beginning on page 58, examines each of these conceptual problems in greater detail. Specific attention is devoted to conceptual problems that, if not remedied, would render the EJ screening tool invalid and unreliable for use in its intended purpose. The points made in Part 2 are summarized below.

The proposed EJ screening tool relies on a model that has a number of serious conceptual problems. These problems come in both procedural and substantive varieties.

Procedurally, OEHHA's failure to disclose critical information has impaired the public's ability to provide meaningful and informed comment.

Procedurally, the ability of the public to review, analyze, and comment on the proposed screening tool is seriously hampered by insufficient disclosure. OEHHA has disclosed the mechanics of its proposed model and references for each of the proposed indicators. OEHHA also has disclosed in map form how scores vary statewide by Zip Code for individual indicators and suites of related indicators, and maps for suites of indicators for nine regions.

However, OEHHA has not disclosed the model itself, the data it used to populate the model, or the outputs of the model. This means the public can comment only on model design and the proposed choice of indicators. It cannot examine the extent to which model outputs are sensitive to alternative model designs or indicators.

Substantively, the proposed screening tool has serious, undisclosed deficiencies that undermine the validity and reliability of its outputs.

Two aspects of the proposed model are particularly problematic: unacknowledged data quality defects, which make comparisons across communities invalid and unreliable, and the use of a relative scale, which is technically inconsistent with the definition of *cumulative impacts* and is undesirable for numerous policy reasons.

These data quality defects are endemic and substantial.

OEHHA ignores uncertainties and limitations in the original data on which it proposes to rely.

OEHHA has ignored known uncertainties and limitations in the underlying data on which it proposes to rely, thereby incorrectly assuming that all differences across geographic units are statistically significant and substantively meaningful. For indicators that are based on estimated quantifies, it is scientifically illegitimate to simply ignore the extent to which differences in estimates across communities are not statistically significant ands instead treat estimates as if they contain no uncertainty. The proper analytic approach is to acknowledge these uncertainties and propagate them through the model.

OEHHA ignores the extent to which these data are technically inappropriate for use in EJ screening.

OEHHA also has simply assumed that data and estimates obtained for other purposes can be automatically transferred for use in EJ screening. There are numerous reasons why this should not be done, but perhaps the most obvious is that EJ screening is a fundamentally different application. Whereas most statistical data sets are created to enable accurate estimation of the middle of a distribution, including most notably measures of its central tendency such as the mean or median, any scientifically legitimate EJ screening tool must be concerned not with the middle of the distribution but with its tails. That means the data must be robust enough to obtain accurate and precise estimates of the tails. No matter how well third-party data might estimate central tendency, what matters is how well it estimates extreme values in the distribution, for that is where severe environmental inequality will reside.

OEHHA proposes to rely on Zip Codes as the geographic unit of analysis even though their heterogeneity in size and composition make them incompatible with EJ screening.

A high-quality geography-based EJ screening tool must be sure to keep like persons and households together and unlike persons and households apart. Otherwise, EJ-related inferences about the population within each geographic unit will be unreliable.

To be useful for EJ screening, geographic units must be spatially compact. Spatial compactness is essential to ensure that indicators of pollution exposure and public health and environmental effects therefrom actually apply to those who reside within unit boundaries. If a geographic unit is too large, residents will be substantially misclassified across multiple indicators. Misclassification will bias scores toward the mean and make it impossible to accurately pinpoint communities at the tail of each indicator distribution, which a high-quality EJ screening tool must be able to do.

Geographic units also must contain roughly the same number of people. Otherwise, California residents will not receive equal weight. Rather, the amount of weight each resident receives will be inversely proportional to the number of persons who reside in the geographic unit. Ironically, such accidents of geography might even qualify as EJ-related adverse effects.

OEHHA proposes to use Zip Codes as the geographic unit of analysis. Zip Codes are inappropriate, however, because they lack the spatial compactness necessary to assure population homogeneity and they do not provide equal representation to all California residents. Whereas Census tracts are designed to maximize spatial compactness and population homogeneity, Zip Codes are not. They include within their boundaries heterogeneous collections of people for whom the U.S. Postal Service has rationalized the delivery of mail, which no one seriously suggests is indicative of potential environmental inequality. Zip Codes also vary significantly in the population they contain—in California, by more than five orders of magnitude. It is inconceivable that OEHHA would think it appropriate to estimate EJ effects in a way that gives some California residents 100,000 times the weight as others.

Because of these problems, each proposed indicator that consists of a population-based rate is inappropriate for inclusion in the model for statistical and technical reasons. Rates are inherently volatile for Zip Codes with small numbers of residents. The purpose of EJ screening is to identify and highlight the tails of indicator distributions, but rates for Zip Codes with small numbers of residents will be artifacts of small size, not any phenomenon of genuine interest for EJ screening.

The inclusion of weakly correlated indicators adds noise rather than signal to the screening model, and thus renders it less capable of making useful distinctions among communities.

As proposed, the screening model relies heavily on pollution exposure indicators that do not measure exposure to pollution, and public health and environmental effects indicators that, at best, weakly measure public health and environmental effects from such

exposure. The addition of scientifically weak indicators adds more noise than signal to the model. This dilutes the ability of the screening tool to even classify communities correctly into broad categories. It biases community scores toward the mean even though the stated purpose of the screening tool is to identify communities that may be located in the tail of the distribution.

The proposed relative scale is inconsistent with the definition of "cumulative impacts" and is undesirable for multiple policy reasons.

OEHHA's screening tool is supposed to implement an agreed upon definition of *cumulative impacts*. The definition begins with exposures to pollution and counts only public health and environmental effects caused by exposures to pollution. A relative ranking scheme is insensitive to the changes in pollution and human exposure. If exposure to a particular pollutant declined below its relevant biological threshold, thus eliminating any public health risk from it, a relative scoring tool would fail to capture this obviously beneficial change. Thus, the definition of cumulative impacts is inconsistent with any EJ screening tools that relies on relative scoring.

Relative scale also is undesirable for several policy reasons. First, relative scoring cannot capture the moral content of environmental inequality, which requires a firm connection to adverse public health and environmental effects caused by pollution. Environmental inequality loses its meaning if relative differences among communities are not interpretable as differences in pollution, exposure to pollution, or their subsequent public health and environmental effects. Under the proposed scheme, some communities will always get high scores even if they do not experience any public health or environmental effects from pollution. That is, a relative tool is incapable of distinguishing real from imaginary impacts.

Second, a relative scoring scheme guarantees that OEHHA will fail to achieve any recognizable reduction in environmental inequality. No amount of reduction in pollution or exposure to it would make any difference. Relative scoring enables OEHHA to reduce a community's high EJ score only by increasing the EJ score of another community. The number of communities with scores exceeding any designated threshold would never change.

OEHHA's EJ screening tool is supposed to be a screening tool, not a thinly disguised regulatory decision-support tool.

Properly designed and implemented, the purpose of a screening tool is to identify which elements within a set of elements warrant no additional investigation or concern. It should be sensitive enough to minimize false negatives, but it need not minimize false positives because no element in the set preliminarily identified as a positive is assumed to be a true positive. Additional investigation and analysis is always required to distinguish true from false positives.

A screening tool is used improperly if no additional analysis is going to be performed to distinguish true from false positives. When that happens, what was ostensibly a screening tool is illicitly transformed into a decision-making tool. Credible

decision tools require selectivity as well as sensitivity in order to distinguish true from false positives. In addition, any decision tool that relies on ranking must be able to credibly distinguish among elements in the set that are ranked.

OEHHA's proposed screening tool lacks the capacity to distinguish true from false positives. In addition, documents published by OEHHA and its staff clearly indicate that the Office does not intend to make any subsequent effort, or apply any other tools, to make these distinctions. That means OEHHA's proposed EJ screening tool actually is a thinly disguised decision-making tool.

This approach is assured of maximizing and perpetuating avoidable controversy. Communities whose scores differ in either direction from prior expectation will reasonably, and perhaps vigorously, dispute the model and its outputs. OEHHA's competence and good faith will become controversial subjects in their own right, for it will be widely understood that the Office knowingly exceeded its charge by devising a regulatory decision tool but mischaracterizing it as a screening tool. These predictable institutional harms can be avoided if OEHHA redesigns its EJ screening tool so that it performs only a screening function that is supplemented by more detailed analysis.

Part 3: A Review of the Proposed Indicators

Pert 3 of this paper, beginning at page 58, raises technical concerns about specific indicators that go beyond the conceptual problems described in Part 2. Many of the proposed indicators are problematic because they are inconsistent with the working definition of *cumulative impacts.* Specifically, several pollution exposure indicators do not measure pollution exposure; most of the public health effects indicators do not measure public health effects caused by pollution exposure; and none of the environmental effects indicators measure an environmental effect caused by pollution exposure. Further, several indicators are structured in ways that are incompatible with Zip Code geography or they fail to measure what they are intended to measure.

Minimum Quality Standards for Indicator Selection

Minimum quality standards include both procedural and substantive elements. Procedurally, indicators used for EJ screening must be transparent enough that members of the public can reproduce OEHHA's results with an insignificant degree of error. OEHHA has correctly emphasized that its model should be easy for nontechnical persons to understand. They cannot do this, however, if OEHHA withholds details that are necessary to reproduce the Office's results.

Substantively, the credibility of any model is enhanced if its components are objectively defined and clearly appropriate for use in their intended purpose. Subjectively defined indicators are readily contestable because they include weights driven by undisclosed policy considerations rather than science. Third party data do not automatically acquire legitimacy if they lack necessary data quality attributes. Uncertainties and limitations in each original data set must be preserved and propagated through the model, not ignored as if they do not exist or are irrelevant.

Proposed Exposure indicators

The proposed model includes certain exposure indicators that capture exposure to pollution, but it also includes exposure indicators that do not. The proposed indicators for ozone and fine particulate matter fall into the former category, but pesticide use and TRI releases do not. The proposed model is ambiguous about what the proposed indicator for traffic density is supposed to measure.

Public Health indicators

Each of the four proposed public health indicators lacks appropriate quality for inclusion in an EJ screening model. None of these health effects is predominantly caused by exposure to pollution. The incidence of low birth weight (LBW) is causally associated with the age of the mother, particularly older mothers who have chosen to delay childbearing and/or require artificial reproductive technology to become pregnant. These are not characteristics of communities that have plausible EJ concerns.

Asthma, cancer, and heart disease may have pollution components, but they are not the most important component. Asthma is a complex condition in which a particular allergic response is observed. It is not scientifically credible to implicitly assume, as this indicator would, that all such responses are caused by pollution. Similarly, cancer and heart disease have multiple etiologies including genetics and lifestyle choices. While some cancer and cardiac mortality may be attributable to pollution, there is no credible scientific evidence suggesting that pollution is anything but a minor contributor.

Each of these indicators also is technically inappropriate as currently configured. The LBW indicator is deficient because it is a population-based rate, and all such rates are susceptible to volatility and arbitrariness in Zip Codes with few residents. To the extent that OEHHA is successful in divining Zip Code-level resolution for cancer and heart disease mortality, which the Office clearly intends to do, the resulting indicators will display the same technical deficiencies as the proposed LBW indicator. The indicators for asthma emergency department visits, cancer mortality, and heart disease mortality are all deficient because they incorrectly assume that lifelong, chronic health conditions can be properly assigned to each person's current Zip Code. The asthma indicator also is biased because it captures only a systematically biased subject of persons with asthma.

Environmental Effect Indicators

Each of the proposed environmental effects indicators is poorly linked, or not linked at all, to pollution exposure. Residential distance to waste sites and similar environmental disamenities may be reflected in real estate values, but it does not follow that these reductions in value are the result of environmental effects from exposure to pollution.

The proposed indicator for impaired water bodies is especially difficult to justify. Zip Codes ostensibly most adversely affected by proximity to an impaired water body in California also happen to be among the State's most expensive and highly coveted residential locations. It is peculiar in the extreme to impute a presumptive EJ-related concern to these communities.

The decision to give special attention to sensitive subpopulations is by definition strictly policy-driven, though it appears to have been substantially influenced by scientific studies reporting that the very young and the very old may be more susceptible to environmental insults. Even if this scientific evidence is assumed to be correct, it is not clear that the Draft Report properly accounts for it. The Draft Report appears to oversimplify the science, attributing sensitivity to a much broader group of people than the science supports. By doing so it gives extraordinary weight to geographic clusters of older adults without regard for why they are co-located, and it confers a benefit on people who in general are unlikely to have legitimate EJ concerns.

Sensitive Population Indicators

The purpose of including these indicators is to capture demonstrable differences in biological sensitivity to pollution of one form or another. Unfortunately, the proposed model oversimplifies biological sensitivity by assuming that it is universal and generalizable rather than occasional and selective. The multiplicative weight in the model has the practical effect of imputing an unequal environmental burden where in the vast majority of cases it either does not exist or is more likely to be negative.

The proposed indicator for age gives special weight to older adults who cluster residentially for reasons that are unrelated to any conceivable EJ concern, such as retirement or (even more perversely) high relative income or wealth.

Socioeconomic Factor Indicators

Some of these indicators reasonably capture bona fide socioeconomic factors that may correlate with environmental inequality, but others do not. Each of these indicators has some correlation with income, but the correlation may be causal (e.g., adult educational attainment) or merely a proxy for one or more unmeasured causal factors (e.g., race and ethnicity).

The proposed indicator for median household income is appropriate when limited to intra-regional comparisons, but it breaks down quickly when applied statewide. The reason is that the cost of living varies dramatically in different regions. If median income is not normalized by regional differences in purchasing power, this indicator will incorrectly imply that rural communities where the cost of living is low suffer disproportionate effects from low income, when in fact they do not. The poverty rate is even more susceptible to this bias because these rates are calculated on a national level.

Alternative Indicators of Population "Vulnerability"

Indicators in the Socioeconomic Factors suite appear to be intended as proxies for factors other than biological sensitivity for which OEHHA wants to give greater weight. This is problematic because the text of the Draft Report and supporting documents use the term "vulnerability" with maximum ambiguity and zero clarity. A credible EJ screening model that incorporates a suite of indicators for vulnerability must include a clear definition of what it means.

If what OEHHA means by community "vulnerability" is its limited ability to withstand a hostile environment, then the Office should be more rigorous about identifying what factors make a community's environment "hostile" and what indicators plausibly measure these factors. Obviously, it also would help if there was a genuine scientific linkage between these factors and the proposed measurement indicators, not just boilerplate text that states a conclusion based on premises not even shown to be relevant.

Of the factors that plausibly limit a community's ability to withstand a hostile environment, it is not clear that community residents would give great weight to purported public health and environmental effects from pollution. This is especially so if the purported public health and environmental effects are quantitatively minor, subtle, or scientifically speculative. Community residents well give much greater weight to factors that are quantitatively major, transparent, or scientifically proven. For example, residents might have trouble understanding how the regulatory status of a solid waste disposal facility increases community vulnerability but have no trouble appreciating how crime, gang activity, and underperforming schools could have that effect.

In Part 1, it was noted that a community's unemployment rate could be a theoretically sound, practically useful, routinely measured, and highly visible indicator of community vulnerability, including community vulnerability to the unintended effects of State efforts to reduce environmental inequality. Data are available at the community but not Zip Code or Census tract level. While finer detail might be welcome, it is important to keep in mind that none of the valid exposure indicators in the proposed model have Zip Code or Census tract-level resolution.

A community unemployment rate indicator would be a useful complement to an income indicator that, as previously recommended, is normalized for regional purchasing power. OEHHA staff already believe that the proposed socioeconomic indicators are highly correlated, and as noted above, each of these proposed indicators has important technical limitations that prevent accurate discernment of the tails of each distribution, an essential requirement for an EJ screening tool. Indeed, it is not clear that any of the other proposed indicators—adult educational achievement, poverty rates, and race/ethnicity—have any genuine value added.

Part 4: Next Steps

Part 4 of this paper, beginning on page 93, sets forth some ideas concerning how OEHHA might proceed to improve upon the proposed EJ screening tool to make it better serve its stated purposes. While the proposed model represents a useful first draft, it has serious deficiencies that need to be remedied before a second draft is published for public review and comment. These deficiencies extend throughout the model and across many of the proposed indicators.

A useful next step would be to examine the model from top to bottom with a comprehensive look at uncertainty. For example, OEHHA could consider the extent to which its proposed screening tool has each of the types of uncertainty that have been identified by recognized scholars in the field.

Before proceeding further, OEHHA also should reexamine its indicators, dispose of indicators that conflict with the working definition of *cumulative impacts*, and introduce new indicators that are consistent with that definition. An EJ screening model that departs from this definition as significantly and extensively as the proposed model would be an unending source of avoidable controversy, especially if it were implemented as a decision tool and thus contrary to the model's stated purposes.

OEHHA needs valid indicators of pollution exposure and public health and environmental effects reasonably attributable to it. If the EJ screening tool is limited to a screening function, then it is sufficient that selected indicators be sensitive enough to capture both true and false positives, with the understanding that no credible conclusions could be reached unless the tool were supplemented with additional tools capable of distinguishing true from false positives. However, if the final EJ screening tool lacks this essential capability but nonetheless is used for regulatory decision-making purposes, there is no limit to the avoidable controversies it would spawn. That would cause predictable damage to OEHHA's reputation and undermine the tool's practical utility by wasting scarce resources attempting to ameliorate false positives, which by definition do not entail true environmental inequalities.

In contrast, simply assembling indicators from multiple third parties, without regard for the underlying quality of their data or their practical utility for what is certain to be a very different use than the one for which the data were originally collected, is a prescription for failure. An EJ scoring tool inn which composite scores are more random than informative is not a constructive step toward implementing the Cal/EPA EJ Action Plan or fulfilling the legislature's intent.

PART 1: THE ECONOMICS OF AMELIORATING ENVIRONMENTAL INEQUALITY

Much of the literature on environmental justice is based on philosophical and sociological theories of political movements. This is self-evident from conventional definitions, which emphasize fairness, equity, and social action. Empirical studies have been fraught with uncertainty and somewhat colored by advocacy. Therefore, it is useful for policymakers and agency decision makers to develop an elementary understanding of the economic implications of implementing an environmental justice (EJ) screening tool.[4] As with many other social problems, devising effective policies can be much more difficult than first impressions might suggest. This is especially so in areas like EJ where every observable phenomenon has multiple competing explanations, and pathways to effective policy may have numerous dead ends. Intuitively appealing policies also can have unintended, counterproductive effects that economic analysis can help uncover.

Alternative Causes of Apparent Environmental Inequality

There could be many reasons for the way pollution burdens and environmental effects are distributed. In this subsection, several possible explanations are discussed briefly, not to exhaust all of the alternatives, but rather to illustrate how diverse these reasons might be. It is not sufficient to simply assert that a particular cause applies in a specific instance; substantial supporting evidence is required to make any such inference. Moreover, not every tool at Cal/EPA's or OEHHA's disposal is appropriate for use in attempting to ameliorate all types of environmental inequality. There is no question, however, that some of the tools Cal/EPA or OEHHA might try to apply could make the intended beneficiaries worse off than if nothing at all were done.

Overt Discrimination

It is certainly possible that poor and disadvantaged communities are targeted for the siting of polluting facilities precisely because they are poor and disadvantaged. This explanation means that private and public sector decision makers choose to spend scarce resources for frankly venal purposes. That is, there are more economically sensible places to locate a power plant, refinery, solid waste disposal facility, or sewage treatment plant, but those seeking to build these installations knowingly and intentionally bypass more economically sensible locations because they would rather spend more just to punish poor and disadvantaged people.

To the extent that any California community experiences environmental inequality due to overt discrimination, it seems unlikely that such discrimination would be limited to environmental matters. Moreover, neither Cal/EPA nor OEHHA have relevant and

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[4] For convenience in exposition, in this paper the acronym "EJ" is used as shorthand for *environmental justice.* Differences in the distribution of exposure to pollutants and the public health and environmental effects of such exposure are referred to as "potential EJ effects." The tool OEHHA seeks to construct is termed an "EJ screening tool," and communities likely to receive a high score are called "EJ communities."

appropriate tools for ameliorating overt discrimination, particularly if it is realized in non-environmental ways.

Low Political Power

Even if there were people motivated to engage in overt discrimination, it would not be possible for them to succeed unless the affected communities suffered disproportionately low political power. Measuring political power is difficult to do. One popular way is to infer it from low voter turnout. This is an unsatisfactory proxy, however. Turnout is higher for contested elections because voters reasonably believe that their votes have greater import in deciding the outcome. In contrast, elections in poor and disadvantaged communities often are the least contested. Therefore, if it is true that low voter turnout is an acceptable proxy for low political power, and communities suffering environmental inequality also exhibit low voter turnout, then it follows that the underlying problem is a lack of electoral competition in these communities. Neither Cal/EPA nor OEHHA have any relevant and appropriate tools for improving electoral competition.

Historical Patterns of Development

The agglomeration of economic activity in specific places is a characteristic feature of human settlement and development. Before the Industrial Revolution, towns were established in places with an abundance of natural resources and natural geographic amenities suitable for transportation, such as ports and rivers. California's capital city exists where it does because of the Gold Rush of 1848, truly an accident of history. Similarly, San Francisco became the destination of Chinese immigrants because of a combination of its location and the Opium Wars of 1839-42 and 1856-60. Access to water for power and transportation was essential for subsequent industrial and agricultural development. That these events led to agglomerations of people and industry is no accident, but rather the normal progress of economic history.

Environmental externalities often are byproduct of historical patterns of development, as the environmental costs of progress may become concentrated downwind and downstream. But the presence of such externalities presumes the prior existence of communities of people downwind and downstream. If such communities do not exist when pollution occurs, environmental externalities are imposed on places but not on people.

Geographic Attributes Favorable to Industrial Development

Some locations are particularly attractive for specific industrial uses. Steam generating power plants need large amounts of cooling water, which requires them to locate on the ocean or adjacent to a significant river or lake. Seaports require shallow, protected estuaries, and airports must have prevailing winds conducive to achieving and sustaining aerodynamic lift. These locations naturally will have higher concentrations of industrial development, with concomitant local environmental effects. In these communities, residential rents and real estate prices will tend to be lower and access to employment will tend to be greater. Both will incline low-income households to choose to live there.

In these situations, it is often observed that industrial facilities were first on the scene, with residential communities being built afterwards. When this happens, it is no longer obvious who is even nominally responsible for local environmental externalities. Are companies taking advantage of poor communities by siting polluting facilities there? Or are low-income people taking advantage of job opportunities, low rents and home prices by choosing to live near these facilities? Understanding the historical order in which development occurred is essential for properly identifying bona fide EJ communities.

Also, this conundrum is not unique to prospective EJ communities. It has become common to observe, for example, residential communities develop near established military bases, only for conflicts to arise over how these bases are used. The problem is usually described as one of "encroachment," but it isn't always obvious whether operation of the military base is encroaching on a neighborhood or vice versa.

Coincident Interests

Communities that rank high on an EJ screening tool might do so because the same features make them attractive to residents and business entities alike. For example, all other things held constant, everyone prefers lower prices, including low prices for industrial land and housing, and shorter commutes to work. But everyone also has an income constraint that limits what they can buy and requires them to make tradeoffs from among competing goods and services. One way households with limited income can balance their budgets is to choose to live in communities with exceptionally low rents and home prices due to the presence of certain environmental disamenities. Were these environmental disamenities absent, rents and real estate prices would be higher and these communities would be less affordable.

Unequal Distribution Due To Rational Governmental Land Use Decision-Making

Local governments routinely use zoning to ensure that similar land uses are located together instead of being scattered at random within their jurisdictions. That is, some areas are zoned for industrial, commercial, or residential use to the exclusion of other uses considered to be incompatible by residents, planners, and elected officials alike. This inevitably leads to the agglomeration of similar land uses in certain places. However, it cannot be reasonably construed as evidence of genuine environmental inequality, much less the kind of inequality that could violate the State's definition of environmental justice. For OEHHA to mistakenly infer that apparent environmental inequalities resulting from local zoning decisions are somehow deserving of amelioration is inconsistent with more than a century of best practices in local government.

Chance

It is natural to try to find an explanation for every phenomenon we observe. Oftentimes, these efforts will bear fruit. But sometimes they will not, and we will be tempted to jump to conclusions based on little evidence.

It is widely believed that random events are distributed more or less evenly in time or space, but this belief is not supported by what we know from statistical theory and experience. Random events often cluster in ways that appear to reflect some underlying

systematic pattern. Analysts apply various statistical techniques to uncover these patterns, but every technique involves a risk of error. It might fail to detect a real systematic pattern, something statisticians call a "false negative." Or they may detect a systematic pattern that isn't real, which statisticians call a "false positive." Both types of errors are important, and there are many ways to try to manage them. One conventional practice is to assume that a detected pattern isn't real unless the likelihood of a false positive is very low, usually 5% or less. An alternative approach is to take account of the costs of each type of error and draw inferences based on what rule minimizes the summed values of both errors.[5]

Remedies Should Take Account of the Reason Apparent Environmental Inequities Exist

Correctly diagnosing the symptoms of a medical condition is but the starting point for devising a treatment plan. The next step is discerning the likely cause. Treating symptoms without understanding the cause will never make the problem go away. Moreover, treating symptoms based on an incorrect diagnosis might make the patient worse.

The same is true for apparent environmental inequities. The five alternative causes discussed in the previous subsection have very different implications. Overt discrimination is surely the most troubling, for example, but it has very different implications than the others, and it is not clear that any plausible remedy would be within the scope of Cal/EPA's statutory authority. Likewise, there is little Cal/EPA could do if a community experiences environmental inequity because its residents choose not to vote, thus resulting in low political power relative to other communities.

For the remaining alternative explanations, it is not clear that bona fide EJ inequities actually exist. If the EJ screening tool gives substantial weight to the mere presence of industrial facilities in communities inherently favorable for that land use, these communities will always rank high on the index independent of how much effort is devoted to reducing pollution.[6] Communities with coincident interests involve residents who have chosen to live near industrial facilities, whether to take advantage of lower housing prices or to be close to employment. Apparent environmental inequalities that result merely from local zoning decisions cannot be seriously considered as legitimate EJ concerns.

Finally, where chance is the best explanation for an apparent environmental inequity, it is hard to know what ought to be done about it. It would be easy to succumb to the pressure to "do something" without carefully accounting for its predictable effects. But it does no favor to EJ communities if the State finalizes an EJ screening tool that fails to provide any relief, or worse, causes existing inequities to be exacerbated.

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[5] The conventional practice is called *frequentist*, and it is the standard approach to hypothesis testing in classical statistics. The alternative approach is called *Bayesian*, derived from principles first elucidated by Rev. Thomas Bayes in the 18th Century.

[6] For these communities, the scoring tool will convey no information that was not already known.

Understanding "Opportunity Cost"

At its most fundamental level, the economics paradigm is about tradeoffs. Individuals and families make tradeoffs every day when they decide how much to work and what to buy. Firms are the intermediaries that produce the goods and services to supply the market with what consumers want. But for consumer desire, no company would expend much energy to make a product or provide a service. Indeed, it is easier to find goods and services that governments have decided ought to be illegal than it is to find goods or services no one wants to buy.

For every individual and family, the resources to obtain what they want are scarce, and scarcity is obviously a much more difficult problem for the poor to manage. A choice to buy any good or service implies a choice not to buy something else. Economists describe the value of buying "something else" as *opportunity cost*. That is, cost shouldn't be measured in dollars or some other monetary unit; that is just a convenient shorthand way for everything in the market to be easily compared. When parents purchase shoes and clothing for their kids, they pay for them in dollars but their *opportunity cost* is the value to the family of the next best use of those dollars. In short, the true cost of obtaining something is what one has to sacrifice to obtain it.

An important implication from this observation is that nothing is free. This is true even for things that appear to be free but really aren't, such as clean air and water, and for things that some people obtain for free only because someone else has paid for them, such as school lunches, employer-provided health insurance, and parking at the local shopping center. Everything worth having has an opportunity cost, even if it seems to be invisible.

Similarly, converting a good or service from a market commodity to a right does not eliminate its opportunity cost. Rather, making something a right only changes the way it is allocated. Instead of having to make a tradeoff between such a good or service and its competitors, individuals and families expect to spend only trivial sums from their limited budgets to obtain things designated as rights. Once something has been made a right, it is no longer allocated by supply and demand in the marketplace. It is allocated by government, and its opportunity cost is borne by citizens and residents in proportion to their share of taxes collected to support the government.

And even that does not eliminate opportunity cost, for the resources available to the government also are limited. The protection and implementation of rights requires the expenditure of sometimes-substantial sums. Thus, the opportunity cost of a right is the value of other goods and services that must be sacrificed in order to obtain and secure that right.

As the State of California has defined it, *environmental justice* means "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and

policies."[7] The importance of fairness in this definition is obvious; the opportunity cost of achieving it is not.

This creates two distinct implementation problems. First, fairness is in eye of the beholder because it generally lacks an objective meaning. It can mean anything from a common set of rules consistently enforced to an equal share of the results. Second, fairness is excruciatingly difficult to measure, especially so when the good or service to be allocated—like environmental justice—is ambiguously defined. If an objective working definition could be agreed upon, it would be easier to reach agreement on what constitutes an environmental inequity. It would be easier to predict whether policies intended to ameliorate it were likely to succeed, or if they had already been implemented, whether they had achieved their objectives. And, we could estimate the opportunity costs of alternative policies. Economics teaches that the best policy is the one that achieves the objective at the lowest opportunity cost.

The Opportunity Costs of Implementing an Environmental Justice Screening Tool Badly

One-size-fits-all solutions make sense only if everyone has the same size. Thus, for environmental justice policies to be effective they must take account of the reasons why different communities experience apparent environmental inequities. Similarly, it is equally essential that prospective remedies be designed in a way that makes them capable of meliorating the problem they are intended to solve. No proposed remedy, however noble in intent, is worth pursuing if it lacks any reasonable chance of improving conditions for the people it is supposed to benefit. The worst thing government can do is devise and implement a remedy that makes conditions worse. Medicine is not the only arena in which cures are sometimes worse than the disease.

Use of the Screening Tool Could Make EJ Communities Worse Off

How Cal/EPA would use a final version of its EJ screening tool is not yet clear.[8] However, some of the ways under consideration appear to be ill advised because they could unintentionally make EJ communities and their residents worse off. That is surely not a result that Cal/EPA or OEHHA intend.

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[7] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2007), citing California Government Code Section 65040.65012(e).

[8] See OEHHA California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2010), iii; hereinafter "CI Report" for a disclaimer stating that "the scientific screening methodology [proposed in OEHHA California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b) hereinafter "Draft EJ Screening Tool Report" or "Draft Report"] is not to be used for regulatory purposes, including the permitting of facilities or compliance with the California Environmental Quality Act." However, that limitation applies only until guidelines for the tool's use are completed. Elsewhere in the CI Report, several potential regulatory uses are discussed.

OEHHA's definition of "precautionary approaches" may unintentionally disadvantage EJ communities.

The CI Report provides OEHHA's scientific foundation for the proposed EJ screening tool. It defines "precautionary approaches" as:

> taking anticipatory action to protect public health or the environment if a reasonable threat of serious harm exists, even if absolute scientific evidence is not available to assess the exact risk.[9]

It is important to understand the implications of this definition on EJ communities. To gain that understanding, it may be helpful to begin by recognizing why people are instinctively precautionary, then think through how to apply this knowledge constructively in an EJ context.

The discussion below shows how the definition of "precautionary approaches" could inadvertently harm the very communities they are intended to benefit.

All seemingly "precautionary" actions aren't necessarily precautionary.

Long before there were mandatory seat belt laws, automobile manufacturers recognized the risks posed to unbelted drivers and passengers and they offered seat belts as a safety option. Not everyone wanted them, but many people did. Later, automobile manufacturers invented and offered air bags as optional safety equipment, and many people willingly chose to have them installed. In both cases, the cost of a car equipped with these safety features was higher than the cost of a car without them. Though it is true that both seat belts and air bags are now required equipment in almost every motor vehicle, the impetus for them came from manufacturers who saw a consumer need and sought to develop products to meet it.

It is important to understand that consumers who willingly purchased these features were not necessarily behaving in a manner that is precautionary with respect to automobile safety. Whether they were precautionary depends on how much they paid to obtain more safety. The point of departure for determining whether a consumer was precautionary is the *expected value* of the additional safety that seat belts or airbags provide. Expected value is calculated by identifying each possible outcome and multiplying its likelihood by its consequences, then summing these products together.[10] A consumer willing to pay no more than the expected value is described as *risk neutral*. A consumer

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[9] OEHHA California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2010), vii.

[10] More formally, the expected value is the weighted average of all possible outcomes, where the weights are the probabilities of the outcomes. For a discrete number of outcomes *N*, the expected value is the sum of $p_1x_1 + p_2x_2 + p_3x_3 + \ldots + p_Nx_N$, where x_i and p_i represent the value and probability of the ith outcome; and $p_1 + p_2 + p_3 + \ldots + p_N = 1$.

willing to pay more than the expected value is *risk averse*, or precautionary.[11] Risk aversion (i.e., precaution) is an essential component of elementary economics and decision theory.[12]

People are naturally precautious.

Being "precautionary"—that is, being willing to pay more than the expected value of a safety improvement, or an environmental amenity—is one of the most natural things people do. Precautionary behavior can be witnessed every day and everywhere. Indeed, the insurance industry would not exist but for the fact that people want protection from the unknown, and they are willing to pay more than the expected value in order to obtain it. Even if California did not require operators of motor vehicles to carry liability insurance, most residents would do so voluntarily.[13]

Some people appear not to be precautious, but on closer inspection they turn out to be just as precautious as others. For example, many Californians happily engage in a variety of extreme sports ranging from skydiving to mountain and rock climbing to bungee jumping. For those not interested in the thrill of apparent physical risk, gambling has become very popular in California. Today there are dozen of established casinos spread out across the State, from Del Norte and Modoc Counties in the north to San Diego and Imperial Counties in the south.

Yet people who seem to love taking risks usually are in fact highly precautious. Few skydivers jump without taking substantial care to ensure that their main parachute will open. They pack a second parachute to protect themselves from the rare case when the main chute fails. Mountain and rock climbers devote extraordinary attention to safety equipment and practices. Companies that offer bungee jumping services always emphasize safety in their advertisements and operations. Deaths from extreme sports do occur, but

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[11] See, e.g., Pearce (1981), 179; Nicholson (1985), 103-108; and Raiffa (1970). A more recent edition of an elementary version of Nicholson's textbook [Nicholson and Snyder (2007), 202-213] covers the same material and is the foundation for the first year course in economics at the University of California at Berkeley. See http://emlab.berkeley.edu/users/cle/e101a_f12/syllabus2012.pdf.

[12] Some consumers who are precautionary with respect to automobile safety nevertheless would not willingly purchase seat belts or airbags, but they still pay more than the expected value for additional safety. They do this by achieving the same reduction in risk other ways, such as by driving in a more precautionary manner, or avoiding highways that lack median separators. There also are consumers who are not precautionary (or who might even be risk takers) who willingly purchased seat belts and airbags despite the price of these innovations exceeding their expected value. For these consumers, the seat belt and airbag enabled them to drive more aggressively.

[13] Regulatory requirements to carry insurance exist to prevent some motor vehicle operators (generally those without assets) from evading financial responsibility for their actions. Market forces alone are not sufficient to prevent these people from imposing costs on others. Economists call such circumstances *externalities*.

they are very rare. Similarly, gamblers are aware of the relative odds of winning different games of chance and choose according to their tastes. For extreme sports enthusiasts and gamblers alike, the challenge is to minimize risk consistent with the excitement they get from the activity.

But people cannot be precautious about everything at the same time.

An unfortunate problem with being precautionary with respect to something is that it requires taking risks with respect to something else. That these other risks may not be as visible does not mean they are any less real.

Suppose that a household has a fixed amount of resources that it can spend to obtain two different goods: environmental health and product safety. If the household is precautionary about environmental health—that is, it would "rather be safe than sorry"—for any amount of environmental health, it will be willing to pay more than the expected value to obtain it. And there is nothing unusual or unconventional about this.

But paying more than the expected value for any amount of environmental health means having fewer resources to obtain product safety. This will not be much of a problem if for some reason the household likes taking product safety risks, but that circumstance seems unlikely. It is much more likely that the household will want to be precautionary about product safety risks, too. In the admittedly stylized world in which there are only these two goods, the household will have no choice but to take product safety risks in order to be precautionary with respect to environmental health risks. What the household has to give up in terms of product safety is the *opportunity cost* of being precautionary about environmental health.

A household that desires to be precautionary with respect to both environmental health and product safety is in a real bind, because it cannot be precautionary with respect to both at the same time. If it is equally precautionary with respect to environmental health and product safety, it will unhappily act as if it is not precautionary with respect to either one. But if it is more precautionary with respect to environmental health than product safety, then it will expend a disproportionate share of its budget on environmental health, and it will unhappily, but willingly, take risks with respect to product safety.

We can add a third good to the household's available choices, and a fourth, and a fifth, or any number of goods we want, but the conclusion will be the same. In order to pay the cost of being precautionary with respect to environmental health, the household has to take risks with respect to *something* else. In the non-stylized real world in which people live, that will mean taking risks with respect to whatever goods and services the household is *least precautionary* about. Precautionary people will differ as to what goods and services they put in this category, but they all will have a category of things for which they had to take risks. For each household, the opportunity cost of precaution will be found here—not so much in money, but in the value of goods and services the household had to do without.

An obvious example familiar to Californians is the choice between automobile gas mileage and automobile safety. Vehicles that get high mileage tend to be small, and small vehicles are less safe. When people purchase vehicles with exceptional fuel economy, they cannot help but accept higher risks of injury or death, both to themselves and their

passengers. These additional risks can be reduced by purchasing unusually safe small cars, but those cars also are more expensive. Spending scarce household budget dollars on additional safety leaves them with fewer resources to spend on other things they value, including things that improve health and safety in other ways.

Governments that are precautionary with respect to public health and the environment must take risks with respect to other things their citizens value.

The State of California, its subordinate agencies, and its local governments cannot avoid these tradeoffs. Governments also have limited budgets. Thus, if Cal/EPA allocates its appropriated resources in ways that are precautionary with respect to public health and environmental quality, it necessarily will have to take risks with respect to something else. It cannot be precautionary about everything within its jurisdiction. What is true for Cal/EPA is true as well for the State as a whole.

The enacted State budget for fiscal 2012-13 allocates 32% for health care (primarily Medi-Cal), 27% for elementary and secondary education, 12% for transportation and housing, 7% for higher education, and 6% for corrections.[14] To be precautionary about public health and the environment means reallocating resources from one of these other uses. Of course, there are plenty of people who want the State to be precautionary with respect to these other uses, too, whether that be health care for the indigent, highway maintenance and improvements, elementary and secondary education, or law enforcement. Many conflicts over State budgeting can be understood as contested efforts to decide which public services deserve a more precautionary attitude.

The consequences of precautionary decisions is much the same for local governments, except that they are magnified by restrictions imposed by the State on both sides of the budget ledger. Some restrictions compel local governments to be more precautionary than they want to about things the State insists on. The opportunity cost of these restrictions to local governments is they are have fewer resources to implement their citizens' precautionary attitudes and preferences with respect to different things. For example, residents in an EJ community might be more precautionary with respect to law enforcement or school quality than environmental health. The State's requirement that they be precautionary about environmental health might reflect the preferences of higher income communities, which do not experience much crime and already have quality schools.

Cal/EPA should apply its definition of "precautionary approaches" in ways that take care not to disadvantage EJ communities by requiring them to make choices as if they were not.

Returning to the definition of *cumulative impacts*, note that it doesn't address the question of what risks must be endured to achieve the additional protection from public health risks and environmental threats that precaution requires—that is, the opportunity

[14] State of California (2012).

costs of precaution. Unfortunately, the definition is written as if opportunity costs do not exist or can be safely ignored. But it does no favor to EJ communities to pretend that this is so, for it is EJ communities that could be the least able to bear the opportunity costs of environmental health precaution. If the residents of EJ communities were asked for their opinions, they might well say that they would rather be precautionary with respect to other things, such as law enforcement or school quality. Indeed, what they might be the most precautionary about is jobs.

> ***EJ communities are especially vulnerable to poorly designed or targeted interventions, even well intentioned interventions that are supposed to make them better off.***

As this discussion makes clear, if the State earnestly desires that every community be precautionary about environmental health, it is essential that the State take account of the opportunity costs borne by each community along the way. For their part, EJ communities may not want to be as precautionary as, for example, the residents of higher income communities elsewhere. EJ communities may prefer other goods and services—goods and services that higher income communities may take for granted—such as crime prevention, better schools, higher quality housing, improved public transportation, and perhaps access to more diverse shopping opportunities. In particular, EJ communities are unlikely to be made better off if State action requires them to be as precautionary with respect to public health and environmental quality as higher-income communities prefer. If EJ communities could control how additional resources provided to them were utilized, it is entirely plausible, if not likely, that they would devote resources first to other purposes.

Perhaps the worst that could happen to an EJ community is if State action imposes new costs on them, thus making the lives of its residents even more difficult. No doubt, State officials would never think of doing this directly, of course. But they might not be aware of how indirect actions could have the same effect. For that reason, any proposed use of a final EJ screening tool should be subjected to very careful examination of its indirect and unintended consequences on EJ communities.

Can Precaution with Respect to Public Health and the Environment Be Achieved by Regulation?

The short answer, of course, is yes, but that answer is incomplete and misleading because it neglects to take account of tradeoffs that cannot be avoided. What must be sacrificed to obtain the next unit of public health and environmental protection? As the baseline level of public health and environmental protection rises, an increasing amount of other goods and services must be foregone to obtain each additional unit. Who actually bears the burden of public health and environmental regulation? It may be convenient to think that someone else can be compelled to make these sacrifices, but mostly this is just wishful thinking. When costs are borne directly by industry, for example, that is usually their first stop on their way to California's households.

Who actually bears the cost of regulation?

When a firm bears financial costs to comply with a regulation, these costs do not simply vanish. Regulatory costs will be shared with—shifted to, really—the following collection of parties:

- Some costs will be shifted forward to **consumers**, in the form of higher prices.
- Some costs will be shifted backward to **suppliers**, in the form of lower prices paid for goods and services used by the firm to make its products.
- Some costs will be shifted to **labor**, in the form of reduced wages, salaries, and benefits.
- Some costs will be shifted to **government**, in the form of lower tax payments on income and sales.
- Finally, some costs will be borne by **capital**, in the form of lower returns on investment.

Which group will bear most of the costs of regulation? The answer will vary depending on each firm's place in its own market. A good point of departure is the assumption that, unless it cannot be avoided, market forces will cause regulatory costs to be passed on to others wherever that is possible.

There are clear circumstances in which this will be difficult. For example, firms in very competitive markets with low gross margins will not able to raise prices to consumers. Companies that purchase commodities to make their products will not be able to reduce what they pay for raw materials. Firms with unionized labor will not be able to shift costs to workers. Every firm that sells less or makes a lower profit will shift costs to the government.

What about capital? The conventional wisdom seems to be that regulatory costs are borne by stockholders, who simply reap lower profits. The problem with this way of thinking is that capital is often highly mobile. It can be removed from a company long before the ink on a regulation is dry. This happens by the simple act of selling the company's stock. Well before a company realizes the direct costs of complying with a regulation, its stock price will have declined to reflect the reduction in the market's expectation of its future profits. Stocks decline in price in response to regulation when the market consensus is that company cannot shift regulatory costs to others.

There is an important exception to this rule, and that is capital held by small businesses, whose stock is not traded in markets. For the owners of these companies, there is no way to escape the lower returns on investment that regulation may cause. But that also means they will be especially quick to shift costs elsewhere. Usually, that means labor. Thus, a good place to look for the actual costs of public health and environmental regulation is in reduced wages, salaries, and benefits paid to employees.

For firms located in an EJ community, this means the same regulation that provides additional public health and environmental protection may also cause workers in that community to be paid less, or even to lose their jobs. If the regulation was a precautionary one, then the actual cost consisted of two parts: the expected value of the additional public health or environmental improvement, plus the cost of being extra careful (that is,

precautionary). This additional "insurance" against public health and environmental risk, purchased through the exercise of precaution, forces workers in EJ communities to bear even higher risks of lower wages and lost jobs.

Differences in preferences between residents of EJ communities and non-EJ communities may be very significant.

People differ in what they like, and how they prefer to spend their income. There are many reasons for these differences including culture, income, and personal taste. We will focus on income because, apart from differences in income, it's not clear how much concern there would be about apparent environmental inequality, or even if environmental justice would persist as an issue.

Public health and environmental protection are what economists call *normal* goods. A normal good is, unsurprisingly, a common thing. How much of it households buy declines as its price rises, and increases as household income increases.[15] Thus, like any other normal good, the amount of it that households want to buy declines as it becomes more expensive. They will also buy more of it the more income they have. This is why it is perfectly normal to observe greater private expenditures on health and environmental quality in higher income neighborhoods.

At the State level, it is usually people who live in higher-income communities who are most supportive of increased expenditures on public health and environmental quality. Greater income enables them to satisfy private wants such as housing and education, but higher income does not translate as easily into public goods, which by definition must be publicly provided, unless they can be provided locally. Public health and environmental protection can be provided locally to a certain extent, but collective action over much larger geographic units often is needed. This requires expenditures and regulations by regional, State, and even national governments. For this reason, public support for environmental goods and services will be strongest in higher-income communities.

Residents of EJ communities, however, will tend to have different preferences simply because they have less income. They will still want public health and environmental

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[15] The terms used in economics to describe these phenomena are *price* and *income elasticity*. Price elasticity is the percentage change in the quantity purchased given a one percent change in price, and is expressed as a negative number. Income elasticity is the percentage change in the quantity purchased given a one percent change in income, and it expressed as a positive number. Demand for a good is said to be price (income) *elastic* if a one percent change in price (income) results in a greater than one percent change in the amount purchased. Conversely, demand is said to be price (income) *inelastic* if a one percent change in price (income) results in less than a one percent change in the amount purchased.

Sometimes a distinction is made between *normal* and *luxury* goods. A luxury good is a normal good where a one percent increase in income results in a greater than one percent increase in the amount purchased. There is considerable evidence suggesting that environmental protection is a luxury good in developed economies and wealthy areas.

quality, but they are unlikely to want as much of it. And, as their incomes rise by small amounts, they will prefer to spend their private resources on other things—things that residents of higher income communities may take for granted, such as basic improvements in housing, education, nutrition, and clothes for their kids.

Therein lies a potential source of significant conflict. No matter how much residents of higher-income communities might care about the poor, it is unlikely that they will prefer to spend additional resources the same way. Residents of higher-income communities will always face the temptation to incorrectly assume that their preferences are the same as those of the poor. Not only will this assumption be false, but acting on this assumption will also have substantial costs. Usually it is poor who have to bear these costs.

Regulatory actions that make EJ communities more expensive places to work or invest will intensify rather than meliorate EJ inequities.

It should be obvious that any regulatory action that imposes new direct costs on residents in EJ communities will almost certainly make them worse off. Thus, Cal/EPA would not want to implement the results of a final EJ screening tool in a way that imposes such direct costs.

The more likely problem is the imposition of indirect costs—costs that are imposed directly on other parties, in the expectation that EJ communities would be exempt, but which normal market forces cause to be passed through to EJ communities and their residents nonetheless. As noted above, this could occur through higher consumer prices, lower payments to suppliers, or reduced wages to workers. It would be especially damaging if new regulatory costs made it harder for firms located in EJ communities to compete, thus causing them to lay off or fire employees. (The same principle applies to firms located <u>outside</u> EJ communities that employ residents of EJ communities as workers.)

It has also been noted that capital is generally the most mobile, and thus the least likely factor of production to actually bear the costs of a new regulation. But there was an important exception to the rule: owners of small businesses, whose invested capital is generally not very mobile at all. EJ communities tend to have a disproportionate number of small businesses, so it would be very easy for these entrepreneurs to be unable to escape the burden of new regulatory costs. Small increases in additional regulatory costs in EJ communities could be disproportionately damaging to employment and investment opportunities.

When thinking about the ramifications of an EJ screening tool, it is worth noting that if it is used in ways that indirectly increase the costs of employment or investment in EJ communities (or in non-EJ communities that employ residents of EJ communities), the practical consequence could be to intensify, not meliorate, the very EJ inequities that the State is trying to reduce.

It hardly makes sense to invest so much effort into devising an EJ screening tool only to discover that actually implementing it makes matters worse. This also could occur in communities on the cusp of being designated as EJ communities. Some could be driven into EJ status as a result of actions taken in good faith to reduce EJ impacts.

Who would bear the costs of regulatory actions that make EJ communities more expensive places to work or invest?

As noted above, the initial and actual incidence of regulatory burdens is not the same. If regulatory actions increase the cost of hiring or retaining employees in an EJ community, wages in the community will decline and unemployment will rise. Similarly, if regulatory actions reduce the rate of return on investment in an EJ community, firms that can shift investments elsewhere in order to maintain the same return (e.g., publicly-traded firms) can be expected to do so. But firms that are uniquely tied to the EJ community generally will not be able to do so. They will endure permanent reductions in the value of their community investments; some will go out of business.

Many of the firms impacted most adversely by lower returns on investment will be owned by minority entrepreneurs. This can be illustrated by comparing California at large with the El Centro Metropolitan Statistical Area (MSA), a community that is likely to include Zip Codes assigned high composite EJ scores with the proposed screening tool.[16]

In 2007, the Census Bureau reported about 3.4 million firms in the State, 0.7 million (21%) with paid employees. (The others were sole proprietorships, the quintessential small business.) Minorities owned 36% of all firms and 27% of all firms with paid employees, paying an average of $28,791 per worker.[17] In the El Centro MSA, however, minorities owned 59% of all firms and 52% of all firms with paid employees, paying an average of $21,252 per employee. The capital invested by these business owners is the least likely to be mobile, meaning that they generally would not be able to move their businesses elsewhere. These entrepreneurs are the least likely to be able to shift regulatory costs to others, and thus they are the most likely to bear the actual cost of regulatory interventions intended to reduce environmental inequality. They are the most likely to be driven out of business by such costs, too.

What communities would benefit If EJ communities were indirectly harmed?

It is also worth considering the opposite question: Would any communities benefit indirectly from regulatory actions that indirectly raise costs in EJ communities? Whether this would happen would depend on the nature of the regulatory action, of course, but some insights can be gleaned from considering a highly simplified hypothetical example.

Consider two communities, one an EJ community and the other a non-EJ community with more or less an opposite score, and an initiative that adds new permitting steps to facilities located in EJ communities for the purpose of reducing a specific, geographically defined EJ inequity. These new permitting steps would increase direct costs on firms located in the EJ community, but not on firms located in the non-EJ community. These

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[16] All data are from the most recent Survey of Business Owners and were analyzed by the author. See U.S. Census Bureau (2012a), Statistics for All U.S. Firms by Industry, Gender, Ethnicity, and Race for the U.S., States, Metro Areas, Counties, and Places: 2007, SB0700CSA2001.

[17] *Minorities* includes racial minorities and Hispanics of any race.

higher costs presage lower profits, with concomitant cost pass-throughs to consumers, suppliers and workers employed by firms located in the EJ community. If the new permitting requirements were substantial enough, firms located in the EJ community would reconsider any planned investments there. From the EJ community's perspective, that would have the obviously undesirable effect of reducing future employment. If the new permitting requirements were really demanding, firms would have to think hard about whether it might be better to move operations elsewhere.

Meanwhile, firms located in the non-EJ community presumably would be exempt from the new permitting requirements. They would have no costs to pass through. There would be no direct benefit to the non-EJ community, but the potential for gaining an indirect benefit could be substantial. Investments that are not made in the EJ community would likely be made somewhere else. That means the non-EJ community could benefit from more demanding permitting requirements imposed on firms in the EJ community. Even more perversely, the more demanding the additional burden imposed on employers in EJ communities, the more they could stand to benefit.

The alternative case of "enterprise zones."

Rather than increase costs in EJ communities through regulation or other means, there are alternative ways to *reduce* their costs, thereby making these communities more attractive places to work and invest. These alternatives, called "enterprise zones," have been around for at least three decades. Though they are not perfect solutions, they make a great deal of sense in principle. Reducing regulatory costs can stimulate investment and promote hiring, which may be what EJ communities need and want most.

The originator of the enterprise zone concept appears to have been Sen. Robert F. Kennedy, who in 1967 proposed a bill to provide such things as federal tax credits and accelerated depreciation to firms located in urban poverty areas. Enterprise zones subsequently developed a bipartisan following.[18]

A proper review of enterprise zones is well beyond the scope of the issues on which OEHHA has sought comment. Nonetheless, it is important to note that the principle on which the concept is based is consistent with elementary economic theory, which recognizes that policies cannot help the poor if they make it more difficult to be poor.

The Scope of Economic Deprivation and Vulnerability in Prospective EJ Communities is Likely to be Large

Spatial variation in economic conditions is thus quite wide, possibly wider than the spatial variation in public health and environmental indicators. There are numerous ways

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[18] The effectiveness of an enterprise zone depends on its design. The better an enterprise zone is targeted to address a well-defined problem, the greater are its chances for success. Typically, enterprise zones offer a suite of tax rate reductions or deductions. An alternative approach involving targeted reductions in regulatory burden could be more effective.

this can be illustrated, such as the average income of community residents or rates of home ownership (a proxy for residents' wealth). Income measurements are complicated by different sources of income, including government transfer payments, much of which are collected by retirees. Home ownership rates help distinguish between communities that are predominantly renters and communities that, though poor, have stronger anchors. The most informative indicator of spatial variation in economic conditions, however, may be the unemployment rate. There may be no greater evidence of economic deprivation in a community than the absence of gainful employment among its residents.

In recent years, unemployment rates in California have been higher than at any time in decades, and higher than the national average. Of course, some counties have fared much worse than others. In July 2012, the countywide average unemployment rates ranged from a low of 6.3% (Marin) to a high of 29.9% (Imperial).[19] Communities in which many residents are out of work are quintessential examples of economic deprivation and vulnerability to a host of external circumstances and events, including those of an environmental nature, though there may not be strong inequalities across communities within a county. Some counties have experienced essentially universal decline due to economic conditions, whereas in other counties the burden of unemployment is disproportionately borne in some communities but not others.

Consider Los Angeles County, for which the average unemployment rate in July 2012 was estimated to be 11.9%. As bad as this is, it masks huge variability. Figure A plots July 2012 unemployment rates for 127 distinct, Census-defined communities in Los Angeles County.[20] Unemployment rates ranged from a low of 2% in Rolling Hills (an incorporated city of 1,860 on the Palos Verdes Peninsula) to a high of 23.3% in Westmont (an unincorporated community of about 32,000 people near downtown Los Angeles). Westmont is one of six communities in Los Angeles County with an unemployment rate exceeding 20%. For residents of these communities, current economic conditions are similar to those that existed during the Great Depression.[21]

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[19] California Employment Development Department (2012b).

[20] California Employment Development Department (2012a). At this level of disaggregation, unemployment rates must be interpreted with caution. The rate is based on labor force figures that are estimated to the nearest 100 persons. Thus, the calculated rate is sensitive to estimation uncertainty, which uncertainty in the estimation of ratios is especially great for small communities. Rolling Hills, for example, was reported to have just 900 persons in the work force, 800 of them employed, and none identified as unemployed. Small errors in estimation could cause large swings in the estimated unemployment rate. The City of Vernon is excluded in this discussion because, though it had a 0% unemployment rate in July 2012, it also had no residents reported to be in the labor force or employed. It is an almost exclusively industrial city, with a 2010 Census population of 112 persons.

[21] The estimated nationwide unemployment rate exceeded 20% from 1932 through 1935.

The burden of unemployment not shared equally across communities in Los Angeles County. Burden sharing would be equal if each community's proportion of countywide unemployment were the same as its proportion of the employed labor force. This ratio would equal unity if every resident in the County belonged to exactly one community.[22]

Figure B plots this ratio for each community in Los Angeles County along with a horizontal line representing equal burden-sharing across communities. Communities are sorted in rank order of their community's unemployment rate, as they were in Figure A. The rank order of community burden-sharing is almost identical; for only 13 of the 127 communities did its rank order change, and these changes were extremely small.

Actual conditions are completely different, as shown by the blue markers for each community. There is a near perfect correlation between a community's unemployment rate and its share of the countywide unemployment burden. The ratio ranges from a low of 0.152 for Rolling Hills to 2.25 for Westmont.[23] That is, Rolling Hills' share of countywide unemployment is about one-seventh of its share of countywide employment; Westmont's share of County-wide unemployment is 2.25 times its share of County-wide employment.[24]

These problems are not limited to Los Angeles County, of course. Indeed, there are 26 federally defined Metropolitan Statistical Areas (MSAs) in California. The average unemployment rate for each is presented in Table 1 below, ranging from 7.7% (Napa MSA) to 29.9% (El Centro MSA). In only four of the 26 California MSAs—Napa, Santa Barbara-Santa Maria-Goleta, San Francisco-Oakland-Fremont, and San Luis Obispo-Paso Robles—were the average unemployment rate lower than the national average (8.6%).

The remaining 22 California MSAs were worse off, and in many cases much worse. Eight of the 10 MSAs with the highest average unemployment rates were in California, as were 13 of the 20 highest MSAs. For many California MSAs with high average unemployment, within-MSA variation is substantial and ranges from bad to catastrophic.

This is illustrated in Figure C, which plots the unemployment rate for communities in the five California counties that include the MSAs with the highest average unemployment rates.[25] The countywide unemployment rate ranges from 29.9% (Imperial) to 14.5% (Stanislaus). As high as it is, the average for Imperial County nevertheless

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[22] In the calculations and figures below, 88,900 (1.8%) of the labor force, 80,700 (1.9%) of employment, and 8,500 (1.5%) of the unemployed are excluded from a community. As a result, the ratio of equal burden sharing is 0.91.

[23] Every community to the right of Carson in Figure A bears a disproportionately greater share of countywide unemployment. The equation ($y = 7.208x + 10.242x^2$, where x ≡ unemployment rate and y ≡ percent of county unemployment divided by percent of county employment) fits the data with $R^2 = 0.99989$.

[24] Later in this comment, OEHHA's proposed four proposed socioeconomic indicators are discussed. None of them is as clear an indicator of economic inequity and community vulnerability as the ratio plotted in Figure B.

[25] MSA and county boundaries are not identical, but differences are not material for the purposes of this presentation.

disguises the fact that two of the eight Census-defined communities in the County have unemployment rates exceeding 40%. Of the 75 Census-defined communities in these five counties, only six have unemployment rates below the national average and 15 have unemployment rates exceeding 30%.

Unemployment is evidence of economic vulnerability; unemployment of this magnitude is evidence of extreme economic vulnerability. Obviously, it is crucial that Cal/EPA take account of these circumstances in devising its EJ screening tool. Less obviously perhaps, but no less important, it is essential that Cal/EPA take extraordinary care not to implement a final EJ screening tool in any way that makes these communities worse off than they already are.

Table 1: Nationwide Rank and Average Unemployment Rate for California Metropolitan Statistical Areas, July 2012 (not seasonally adjusted, preliminary)

Rank *(1 to 372)*	**California Metropolitan Statistical Area (MSA)**	**Unemployment Rate**
141	Napa, CA MSA	7.7
164	Santa Barbara-Santa Maria-Goleta, CA MSA	7.9
211	San Francisco-Oakland-Fremont, CA MSA	8.5
211	San Luis Obispo-Paso Robles, CA MSA	8.5
—	*U.S. Average*	*8.6*
217	Santa Rosa-Petaluma, CA MSA	8.6
222	San Jose-Sunnyvale-Santa Clara, CA MSA	8.7
253	San Diego-Carlsbad-San Marcos, CA MSA	9.2
273	Oxnard-Thousand Oaks-Ventura, CA MSA	9.4
282	Salinas, CA MSA	9.5
290	Santa Cruz-Watsonville, CA MSA	9.7
318	Vallejo-Fairfield, CA MSA	10.3
328	Sacramento--Arden-Arcade--Roseville, CA MSA	10.7
333	Los Angeles-Long Beach-Santa Ana, CA MSA	10.9
355	Riverside-San Bernardino-Ontario, CA MSA	12.7
357	Chico, CA MSA	12.8
359	Redding, CA MSA	13.1
361	Bakersfield-Delano, CA MSA	13.6
362	Madera-Chowchilla, CA MSA	14.1
364	Hanford-Corcoran, CA MSA	14.5
365	Fresno, CA MSA	14.7
366	Stockton, CA MSA	15.1
367	Modesto, CA MSA	15.7
368	Visalia-Porterville, CA MSA	15.8
369	Yuba City, CA MSA	17.3
370	Merced, CA MSA	17.5
371	El Centro, CA MSA	29.9

Source: U.S. Bureau of Labor Statistics (2012)

Figure A: Los Angeles County Unemployment Rates
127 Census-Defined Communities, July 2012

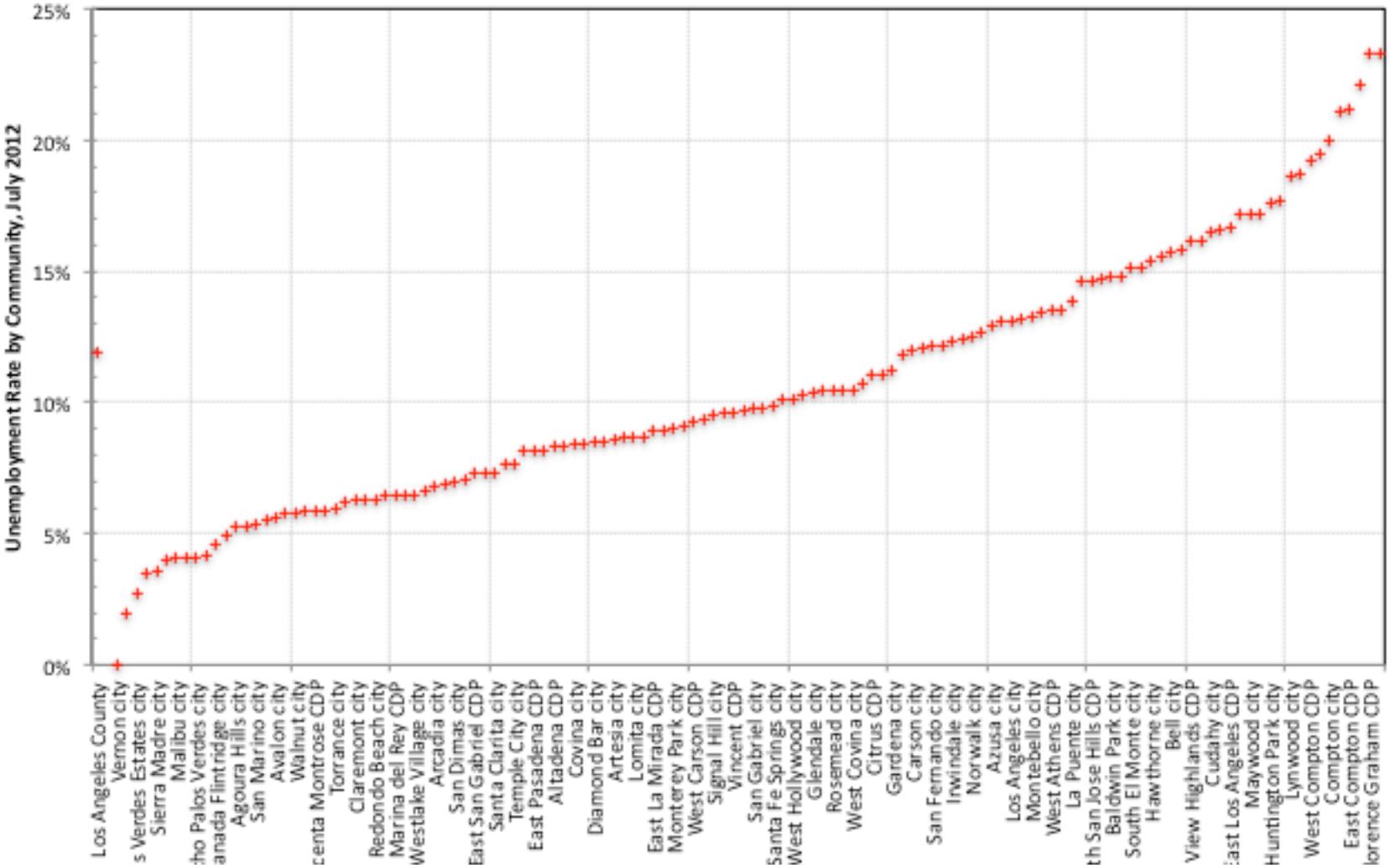


Figure B: Relative Burden of County-Wide Unemployment in Los Angeles County: 128 Communities, July 2012

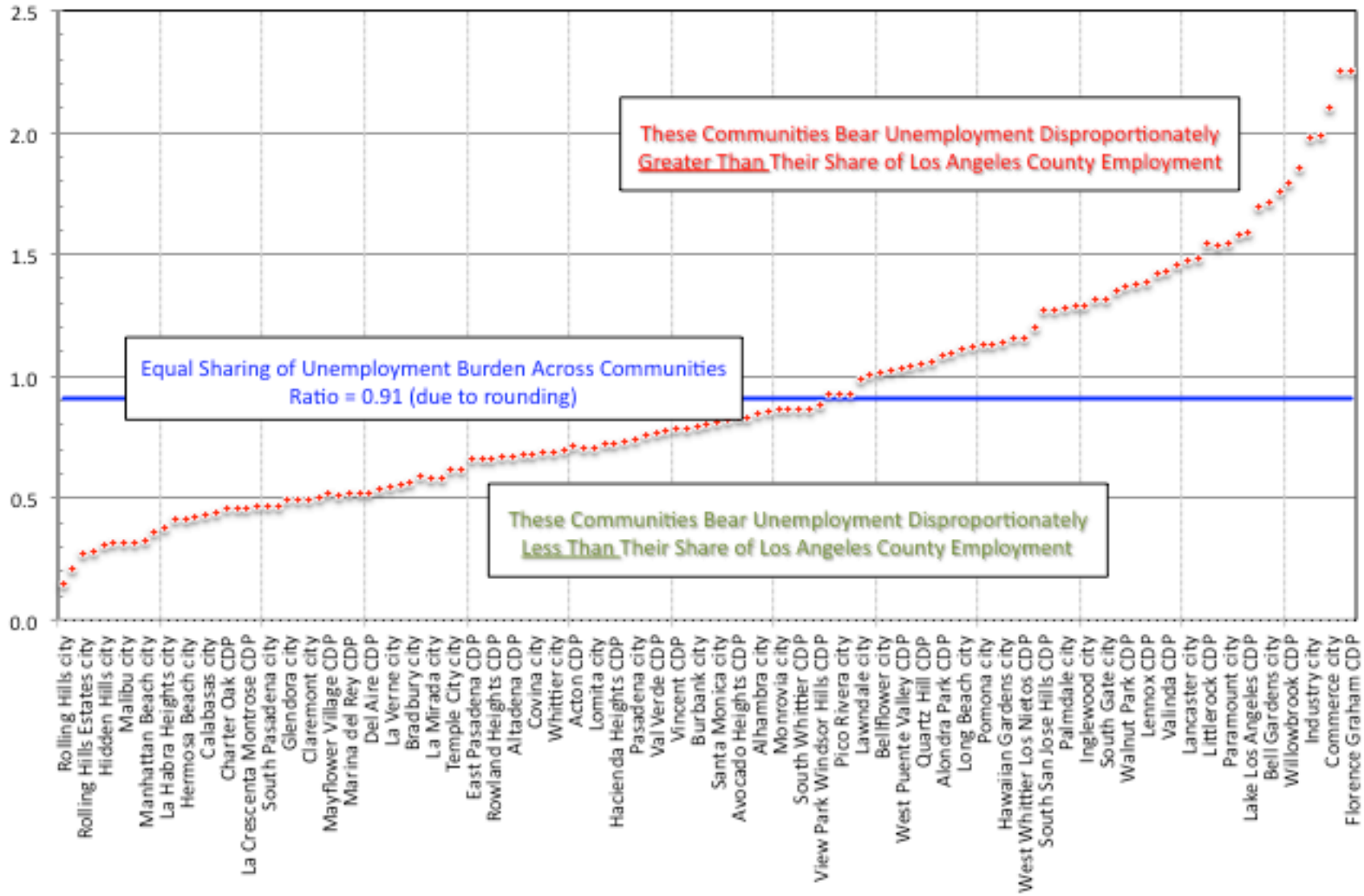
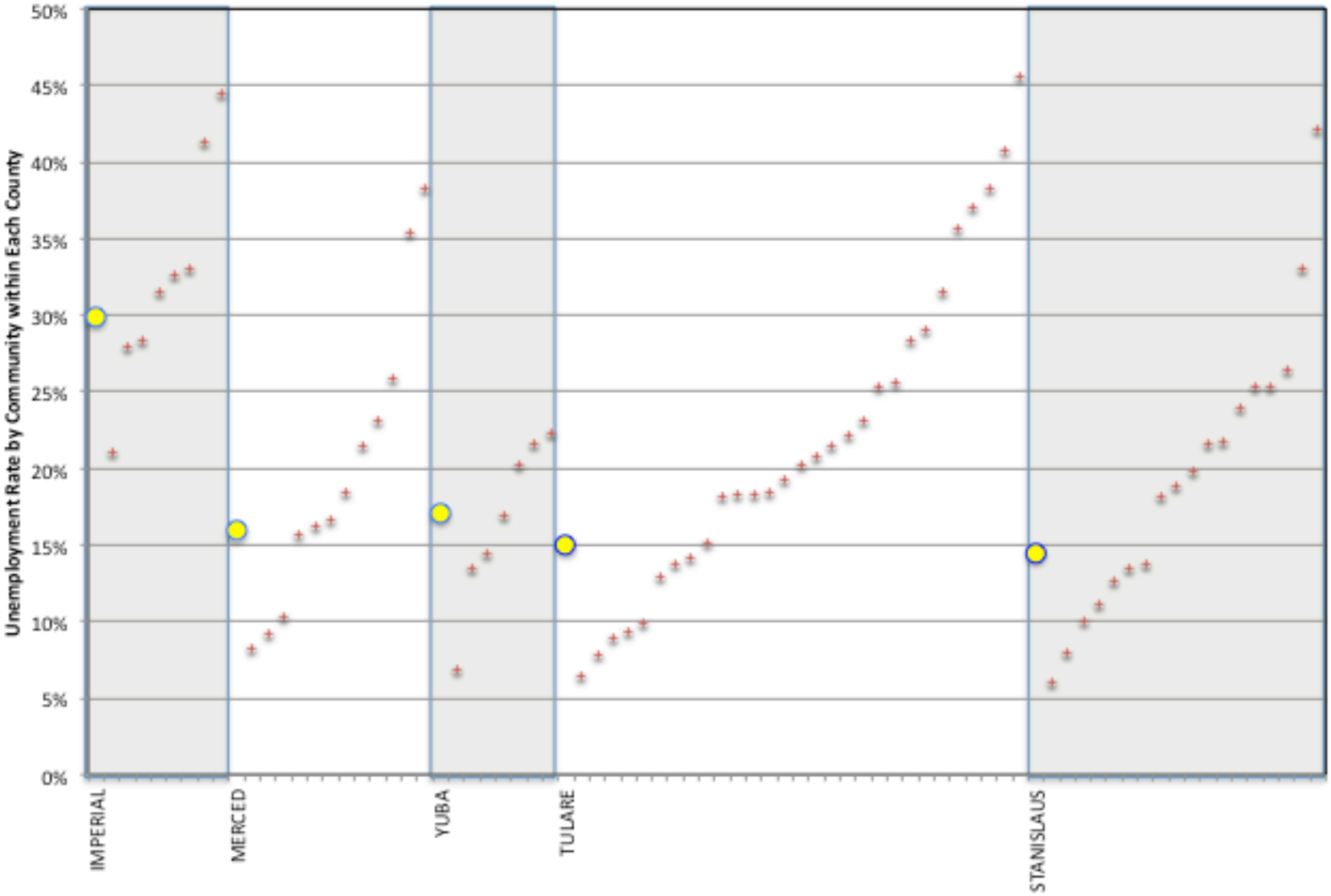


Figure C: Unemployment Rates by Community in Five California Counties with Highest Average Unemployment Rates, July 2012



PART 2: CONCEPTUAL ISSUES POSED BY THE PROPOSED EJ SCREENING MODEL

Before any specific aspect of the proposed screening tool, it is important to highlight some conceptual issues that apply to the entire endeavor and which should be recognized and addressed. Three such issues are identified and discussed here.

First, the proposed screening tool relies on third-party data that have a number of important data quality problems and limitations that have not yet been properly accounted for. These include problems with the use of Zip Codes as the geographic unit of analysis, a lack of attention to what constitutes the smallest effect size that is meaningful for this application, and the absence of any accounting for uncertainties in the data. (This is different from uncertainties with respect to the choice of model, which may be illuminated in part by sensitivity analysis.)

Second, the proposed use of a relative rather than absolute scale creates a host of technical problems as well as difficulties in public communication and implementation. Although the proposed tool is described as a screening tool, it actually behaves as a ranking index that is missing the necessary information quality attributes a ranking index requires to be valid and reliable.

This leads to a third conceptual problem: the proposed screening tool is not designed in a way that is compatible with screening. Rather, it is designed as a decision support tool, and based on information provided in the Draft Report and supporting documents, it appears that OEHHA intends for the tool to be used for a host of decision-making purposes, including regulatory decision-making.[26]

Fourth, contrary to claims made in the Draft Report and elsewhere, the proposed screening tool does not appear to adhere to the definition of *cumulative impacts.* The definition has a certain internal logic that the proposed tool does not actually follow.

Before discussing each of these conceptual issues, however, it must be noted that the proposed screening tool is difficult to review because the Draft Report does not disclose enough information. The public cannot adequately review the model, how OEHHA has processed the raw data, or the implications of OEHHA's proposed indicators based on what has so far been disclosed.

Limitations Imposed on Public Review by Insufficient Disclosure

The purposes of the preliminary statewide analysis presented in the Draft EJ Screening Tool are stated as follows:

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[26] For an obvious example showing how these incompatible purposes are conflated, see August, Faust, Cushing, Zeise and Alexeeff (2012), 3069: "The goal is to identify communities that warrant further attention [a screening function] and to thereby provide actionable guidance to decision- and policy-makers in achieving environmental justice [a decision-making function]."

- To demonstrate the application of a practicable and scientifically justified methodology for evaluating cumulative impacts.
- To provide a baseline assessment and methodology which can be expanded upon and updated periodically as important additional information becomes available.
- To identify communities in California that are most burdened by pollution from multiple sources and are most vulnerable to its effects, taking into account their socioeconomic characteristics.
- To provide as final output a relative, rather than absolute, measure of cumulative impacts as reflected in the statewide ranking of communities.[27]

The extent to which the proposed tool meets these purposes cannot be independently determined because OEHHA has not made public either the tool itself or its outputs (except for selected maps). The public can only comment on the Draft Report as published; it cannot review the validity and reliability of the data used to populate the model; it cannot examine how each indicator or set of indicators contributes to the total score; and it cannot test the effects of alternative indicators on composite scores.

The draft screening tool also lacks scientific justification, even if it is stipulated that every scientific conclusion in Chapter 3 of the CI Report is true.[28] In particular, the scientific links between the technical conclusions in the CI Report and the actual indicators proposed for use are simply assumed; they are nowhere documented. Whether these assumptions have any rational basis cannot be evaluated unless and until a more complete disclosure is provided.

Data Quality Problems

There are several major data quality issues that are not addressed in the Draft Report. Each of them results in significant unacknowledged uncertainty that make it difficult, if not impossible, for OEHHA to describe with confidence how to correctly interpret results. This cannot help but lead to substantial public confusion, misunderstanding, and probably to misuse of the tool for decision-making purposes instead of screening.

Inadequate Attention Was Devoted to Accounting for Uncertainties in the Underlying Data with Respect to Their Original Purposes

For each proposed indicator, OEHHA appears content to assume that original data are fixed, accurate, and as precise as reported in the original source. None of these assumptions is valid. All indicators that rely on measurement or estimation contain uncertainty, some also have embedded errors, and an unknown number contain excess

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[27] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 1.

[28] I have not evaluated the scientific claims made in the CI Report. However, public comments on the draft report indicate that many of these claims were scientifically controversial, and I am not aware of any official response-to-comments document.

precision. It is troubling enough when the limitations of original data are not fully reported or characterized. Careful attention must be devoted to ascertaining error bounds, biases resulting from measurement or estimation error, and the true precision of the original data. Each limitation should be accounted for in the analysis of whether an indicator ought to be included and propagated through out the model.

Inadequate Attention Was Devoted to Accounting For Uncertainties in the Underlying Data with Respect to Their Use for the Secondary Purpose of EJ Screening

The Draft Report does not include any discussion of the extent to which data obtained for other purposes has quality attributes consistent with their use for EJ screening. Rather, suitability for this secondary purpose seems to have been simply assumed.

By the very nature of EJ screening, it is essential that each indicator demonstrate extraordinarily high quality estimation of the tails of the indicator distributions, for that is where EJ effects presumably would be located. Indicators that do an excellent job of characterizing the central tendency or middle quartiles of a distribution cannot be assumed to characterize the tails with the same accuracy or precision. Estimating the tails of distributions with the same accurately as the central tendency requires substantial oversampling of the domains in which the tails reside. It is exceedingly rare for a data collection effort intended to accurately estimate central tendency to oversample to obtain similar quality estimates of the tails. This happens only when there is a special a priori interest in obtaining accurate estimates of extreme values.

Indicators that have weak data quality properties at the tails should not be even considered for use in EJ screening, for their inclusion will add more noise than signal. This, in turn, will cause composite scores to be biased toward the mean, an unacceptable result when the objective is to accurately identify the tail of the composite score distribution.

Statistically and conceptually meaningful minimum effect sizes need to be defined.

A systematic weakness of the approach used in the Draft Report is that every difference in indicator scores is presumed to be meaningful, both statistically and in the native units of whatever the indicator measures. That is, if two communities differ by one unit on a particular indicator, it is assumed that this difference is qualitatively, quantitatively, and statistically important. All values for all indicators are assumed to be fixed and certain, with no more and no less precision than the last digit reported in the original data set, which is presumed to have been reported accurately and without excess precision. These assumptions are very unlikely to be true. For indicators that are constructed ordinal ranks (e.g., pesticide use, proximity to cleanup sites and waste disposal facilities, population sensitivity due to age), classifications are inherently arbitrary. Yet it is assumed that the resulting distribution of scores can be meaningfully described in percentiles and that rank-orderings are accurate.

For indicators that are measured quantities, not every difference between geographic units has information content. Statistical tests must be applied to discern whether differences are more likely to be real or the result of chance. Treating random differences in ranking as if they are meaningful mislead decision-makers and the public concerning what they actually mean. This greatly increases the likelihood that composite scores will be misinterpreted and misapplied.

Zip Codes Are Too Heterogeneous in Composition for Use as the Geographic Unit of Analysis

According to the Draft Report, OEHHA decided to use the Zip Code as the geographic unit of analysis because OEHHA believes that Zip Codes meet several criteria, listed as follows:

- A useful scale for a wide range of decisions.
- Encompass all the people and places of relevance to possible decisions.
- As small as possible, but not so small that it suggests a level of knowledge of local impact greater than can be determined from current statewide data.
- Not so large that the analysis loses power to discern differences due to averaging across the area.
- Publicly established. (Using an existing geographic unit is much easier than creating a new one for the purpose of the project.)
- Familiar scale to the general public.[29]

These criteria may seem reasonable, but Zip Codes are not the only unit that would qualify, unless extraordinary weight is given to familiarity, which in any case may be overrated. Advancements in GIS technology, some of which OEHHA appears to be taking advantage of, make it easy to use unfamiliar geographic units without cost in public misunderstanding. A search utility could be created allowing anyone to find out the EJ score for any address in the State. Moreover, such a feature would enable OEHHA to base the precision of the tool on the quality of the data and refrain from altering the data to fit the geographic unit.

More important than any of these concerns, however is the notable absence from the list of criteria the most important criterion of all for any GIS-based EJ screening tool: homogeneity. Every geographic unit for which OEHHA might want to make EJ-related inferences must be homogeneous on as many margins as possible that are relevant to the selected scoring indicators (the independent variables) and to environmental inequality (the dependent variable). This obviously includes measures of exposure, and public health or environmental effects from exposure. But it also includes indicators used to account for sensitivity or vulnerability, as well as socioeconomic differences such as "population

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[29] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 4. It is not clear whether these criteria were established ex ante or were assembled after the decision was made to use Zip Codes.

characteristics, economic status, and living conditions," the homogeneity of which is a defined feature of the Census tract.[30]

Zip Codes lack any of these desirable qualities. They were created for entirely different and unrelated purposes:

> The ZIP Code system was created and designed to provide an efficient postal distribution and delivery network. ZIP Code assignments are, therefore, closely linked to factors such as mail volume, delivery area size, geographic location, and topography, but not necessarily to municipal or perceived community boundaries. The general stability of boundaries is essential to prompt and accurate distribution of mail. However, delivery growth and changing demographics can necessitate adjustments to ZIP Code boundaries in order to achieve United States Postal Service objectives.[31]

Moreover, there is no reason to expect that any prospective indicator useful for EJ screening would have resolution at the Zip Code level except by accident, unless perhaps the quality of mail delivery is considered relevant for EJ screening purposes.

The Draft Report notes that the Census Bureau version of the Zip Code (the Zip Code Tabulation Area, or ZCTA) overlaps USPS Zip Codes, using the example of Zip Code/ZCTA 90248.[32] Even if it is assumed that ZCTAs and U.S. Postal Service (USPS) Zip Codes overlap perfectly, however, it does not mean that either of them is an appropriate geographic unit for EJ screening.[33] Consistency between ZCTAs and USPS Zip Codes is relevant only if USPS Zip Codes are themselves appropriate. With respect to EJ screening, however, they are not. Zip Codes are heterogeneous groups of people grouped together for the delivery of postal mail, and for EJ screening they are crude, arbitrary, and scientifically unjustifiable.

Because ZCTAs were never intended to define *community* boundaries, they have no necessary relationship to the boundaries of prospective EJ communities. Thus, OEHHA is proposing to implicitly delegate the task of defining community boundaries to the USPS.

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[30] U.S. Census Bureau (2000).

[31] U.S. Postal Service (2012), emphasis added. How often Zip Codes are changed is not easily researched. The Census Bureau reports that significant changes in ZCTAs occurred between the 2000 and 2010 censuses, and that the Postal Service "makes periodic changes to ZIP Codes to support more efficient mail delivery." See U.S. Census Bureau (2011).

[32] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 10.

[33] Regarding ZCTAs, see U.S. Census Bureau (2012e): "ZIP Code Tabulation Areas (ZCTAs™) are a statistical geographic entity produced by the U.S. Census Bureau for tabulating summary statistics from the 2010 Census, first developed for Census 2000. This entity was developed to overcome the difficulties in precisely defining the land area covered by each ZIP Code™, which is necessary in order to accurately tabulate census data for that area" (emphasis added). The Census Bureau has identified 1,678 ZCTAs for California.

While there is no doubt that this would be convenient for OEHHA, as a substantive or policy matter it seems extremely peculiar.

During the Academic Workshop, several participants raised similar concerns about Zip Codes and indicated a strong preference for Census blocks and/or tracts. A related concern specific to the EJ context also was raised—the extent to which plausible EJ communities might be contained within, and overwhelmed in numbers by, Zip Codes that are predominantly not EJ communities. Specifically, it was suggested that the features that make Marin City a plausible EJ community might be diluted to the point of nonsignificance because it shares ZCTA 94965 with the Town of Sausalito.

These two communities are obviously very different, as is shown in Table 2 below. Demographically, Marin City is 38% black and 14% Hispanic; Sausalito is 1% black and 4% Hispanic. Half again as many residents of Sausalito are married couples with families. Economic circumstances also are very different. Median and mean household incomes are twice as high in Sausalito as they are in Marin City. Likewise, the unemployment rate in Marin City is twice as high. Almost 18% of Marin City residents receive food stamps; it is estimated that none of the residents in Sausalito do. It was estimated that every woman residing in Sausalito who gave birth was married, but about half of all women residing in Marin City who gave birth were not.

The concern about Marin City being drowned out by Sausalito is a reasonable one. The population of Sausalito is about three times larger than the population of Marin City. Thus, any indicator that is explicitly or implicitly weighted by population will give three times the weight to Sausalito that it gives to Marin City. No matter how deserving Marin City might be for designation as an EJ community, it is likely to be overwhelmed by Sausalito's greater numbers of residents and highly non-EJ characteristics.

Zip Codes Are Too Variable in Size for Use as the Geographic Unit of Analysis

The number of residents in a Census tract is between 1,500 and 8,000, with an optimal size of 4,000, all residing within the same county and preferably the same community.[34] Zip Codes are much more variable. In the 2010 Census, there were 1,769 California ZCTAs for which data were reported. The population in each California ZCTA ranged from zero (10 different ZCTAs) to 105,549 (ZCTA 90650), with a mean of 21,068 and a standard deviation of 21,316.[35] Sixty-four ZCTAs have less than 100 people; 352 have less than 1,000.

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[34] U.S. Census Bureau (2012b): "When first delineated, census tracts are designed to be homogeneous with respect to population characteristics, economic status, and living conditions. Census tract boundaries are delineated with the intention of being maintained over many decades so that statistical comparisons can be made from decennial census to decennial census."

[35] U.S. Census Bureau (2012a).

This variation plays havoc with the screening tool several ways. For example, as noted above, Zip Codes (and ZCTAs) are not intended to be homogeneous. And as their size increases, Zip Codes become less heterogeneous and more a collection of relatively homogeneous groups of people arbitrarily categorized together. As the example of ZCTA 94565 shows, even a Zip Code with just 10,000 people can include multiple, relatively homogenous communities. For ZCTA 94565, and no doubt many others, it is impossible to make valid and reliable inferences when the geographic unit consists of highly disparate groups. An EJ screening tool with this obvious defect has little predictive value for its intended purpose.

Table 2: Selected Characteristics of Residents from Two Communities within ZCTA 94965 (2006-10 American Community Survey)

Characteristic	Marin City	Sausalito	ZTCA 94965
Population	2,152±269	6,506±159	10,847 (2010)
Black	38.1%	0.9%	10.1%
Hispanic	13.7%	4.1%	6.4&
Fertility rate/1000, women 11-50 --% unmarried	33±35% 44.7±53.3%	28±26% 0.0±48.5%	N/A
Married couple family	26.5±8.7%	35.8±5.0%	32.1%
Owner-occupied housing unit	33.6±9.8%	48.9±5.0%	48.1%
Median home value	$626,800 ±51,286	>$1,000,000	>$652,000
Median monthly rent (2000)	$1,263±502	>$2,000	>$2,000
Median household income	$49,259 ±30,183	$101,910 ±16.456	Homeowners: $94,711 Renters: $67,257
Mean household income	$75,259 ±15,281	$147,347 ±19,944	$76,808 *
Unemployment rate	10.3±5.9%	4.8±2.3%	N/A
SNAP	17.7±7.1%	0.0±0.9%	N/A
% families < Poverty Line	31.1±14.7%	2.2±2.5%	N/A

Sources: All U.S. Census Bureau (2012a), except * (http://www.zipareacode.net/zip-code-94965.htm).

Second, variation of this magnitude, particularly at the low end, means certain types of indicators cannot be used. Zip Codes with few people are highly sensitive to the effects of measurement error, misclassification, and simple randomness, especially for phenomena that are uncommon or rare. This problem is especially acute with respect to indicators expressed as ratios or percentages, which are volatile in both the numerator and the denominator.[36]

Third, an EJ screening tool that relies on geographic units of analysis that vary in population size by five orders of magnitude would treat Californians in a highly inequitable manner. The proposed tool would yield a composite score for each Zip Code regardless of its size, then rank all Zip Codes without prior re-weighting. A Zip Code with a population consisting of only one person would be given the same weight as a Zip Code in which 100,000 people reside, an obviously inequitable procedure.[37]

Indicators Should Retain the Geographic Unit of Analysis for Which They Were Intended

Each indicator selected should retain its inherent data quality characteristics, one of which is the native geographic unit of analysis. Composite scores should retain this information and propagate it throughout the model. OEHHA should not attempt to force greater precision on an indicator than was designed or implemented to provide less geographic detail, nor should it discard valid fine geographic detail just to satisfy a larger geographic unit. Both procedures add uncertainty and error to the composite scores.

Problems Associated with Using a Relative Scale

For several scientific, technical and policy reasons, OEHHA should reconsider its decision to design the EJ screening tool using a relative scale.

No Scientific Justification is Given to Support a Relative Scale

The Draft Report does not provide a scientific or technical justification for using a relative scoring scheme. The text clearly indicates OEHHA's preference for relative scoring, but it does not explain the basis for this preference.[38] Internal references to the CI Report

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[36] This problem is described in more detail in the discussion of Low Birth Weight as a proposed indicator, beginning on page 57.

[37] Analysis with respect to the application of civil rights law is beyond the scope of this paper.

[38] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b)e.g.: "The tool compares areas of the state against other areas, creating a relative ranking," Preface 1; "The method can be used to provide relative rankings of California communities based on cumulative impacts," 1; "[S]ince the goal is to characterize the geographical community for relative ranking, it is not necessary to include all available data, but to focus on the data that are most important and meaningful," 5. It is worth noting that all of these references describe the EJ tool as a ranking device, not a

are similarly not illuminating, as the rationale provided there for relative scoring ranking also would support an absolute scoring scheme.[39]

A relative scale is inconsistent with the definition of *cumulative impacts* that the screening tool is supposed to implement. The definition clearly states that only public health and environmental effects from pollution are relevant. If that is so, then the absence of exposure must preclude the existence of EJ-relevant effects. Similarly, reductions in exposure, however they are achieved, also must reduce the size of the domain of effects captured by the screening tool.

There are also strong policy reasons why a relative ranking scheme ought not be preferred for EJ scoring, even if it might be reasonable for other uses such as allocating enforcement resources.[40] OEHHA should take a closer look at these concerns to be sure that it really wants its EJ scoring tool to have these undesirable qualities.

Relative Scoring Is Technically Incompatible with EJ

Relative scoring systems are appropriate for circumstances in which there are no policy values attached to the size of the domain. Thus, it makes sense to rank physicians, plumbers, and universities on various dimensions. In none of these applications does anyone believe that the size of the domain should be smaller. Consumers of medical care, home maintenance, and post-secondary education have a legitimate interest in ascertaining the relative quality of competitors so they can make more informed judgments about what to purchase.

That is not true for pollution and its effects, for which the desired (if not realistic or optimal) quantity is zero. Similarly, if environmental justice is to have any moral content, then it must be a desirable state of the world where its antithesis is not. A relative scale for quantifying environmental inequality implies that the government's purpose is not to reduce it, but rather to redistribute it.

Relative Scoring Is Insensitive to Demonstrable Reductions in Pollution Exposure and its Effects on Public Health and the Environment

It is easy to envision highly desirable changes in environmental quality that a relative scale cannot capture. Imagine a technology that could be adopted at no cost, which everywhere reduced, by half the raw values of every indicator of pollution or its effects. After the adoption of this new technology and the realization of its beneficial effects,

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screening tool. The difference between screening and ranking is discussed in the following subsection.

[39] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2010): "This screening methodology is not designed to serve as a quantitative assessment of community health impacts, nor is it intended to support 'redlining' of communities. It can be used as a relative ranking method to distinguish higher-impacted communities from lower-impacted communities and may help identify which factors are the greatest contributors to cumulative impact," ix.

[40] Ibid., 34.

community scores on the indicator would be unchanged, even though it is undeniable that everyone in the State would have clearly and enormously benefited. Composite EJ scores would not change for any community.

Relative Scoring Prevents Cal/EPA from Making Progress on EJ

A relative scale for cumulative impacts means that these impacts are permanently inscribed in whatever decision-making systems utilize it. No matter what is done, the accounting for cumulative impacts would be a "zero sum game." Improvements in scores in one community must be matched by declines in scores elsewhere. Again, this makes sense for ranking physicians, plumbers, and universities, for every successful effort by one of them to obtain a higher rank necessarily and appropriately results in another one obtaining a lower rank.

But a relative scale cannot make sense for reducing the cumulative effects of pollution. Reductions in exposure, however achieved, necessarily reduce subsequent public health and environmental effects as long as current exposure is great enough to cause them. However, where current exposure is too low to cause public health or environmental effects, it is scientifically impossible for additional exposure reductions to make any difference.

In this regard, the proposed relative scale is fundamentally at odds with the definition of cumulative impacts upon which an EJ screening tool depends for its policy legitimacy. The definition clearly states that relevant public health and environmental effect are those caused by pollution. Effects that are not caused by pollution lie outside the definition. Regardless of what one believes about the causal relationship between various exposures and resulting effects, no one seriously believes that these effects can occur without exposure.

As long as California continues to host industrial facilities, generate electricity, build and maintain highways, or manufacture products for sale, the communities in which these activities occur are predestined to score high on a relative scale of cumulative impacts. It will not matter how clean they are, or how much public health risk is eliminated by technological controls, or any other factor one might imagine. Closing them down would not help, either, for if exposure is ignored a closed industrial facility can be construed as imposing at least as great an environmental effect as an operating one.

Further, the communities in which these facilities reside, whether closed or operating, will always be stigmatized as bearing EJ impacts simply because there will be other communities that do not host such facilities, even while benefiting from their location elsewhere. A relative scoring system implicitly says that there is no place in the State where industrial facilities could be located without raising a host community's EJ score.

For Cal/EPA, a relative scoring system means it is predestined to fail in the task of reducing cumulative impacts. There is nothing Cal/EPA could do alleviate system-wide EJ inequities. It can only redistribute them to communities that currently do not experience them. Every community whose rank on a relative EJ scoring system declines must be accompanied by another community whose score increases.

Problems Associated with the Definition of "Cumulative Impacts"

The CI Report committed OEHHA to devise a screening tool consistent with the following definition of *cumulative impacts*:

> Cumulative impacts means exposures, public health or environmental effects from the combined emissions and discharges, in a geographic area, including environmental pollution from all sources, whether single or multi-media, routinely, accidentally, or otherwise released. Impacts will take into account sensitive populations and socioeconomic factors, where applicable and to the extent data are available.[41]

Previously, it has been shown that a scoring tool that relies on a relative rather than absolute scoring system is incompatible with this definition. With relative scores, calculated cumulative impacts are fixed in magnitude; they never increase nor decrease irrespective of what happens to actual cumulative impacts.

There are other ways in which the proposed tool is incompatible with the definition of cumulative impacts. To see why, we must examine the sentence structure and how embedded terms are defined.

Emissions are pollutants discharged into the atmosphere, and discharges are pollutants emitted into surface water, ground water, or onto land. Thus, all effects that comprise cumulative effects begin with an emission or a discharge. If neither an emission nor a discharge occurs, there cannot be a cognizable "impact".

Exposures are potential human health effects "from" pollution emissions and discharges. Public health effects are actual human health effects "from" pollution emissions and discharges, and environmental effects are actual non-human health effects "from" emissions and discharges. This is a logical assembly of the array of phenomena that could be included in a CI model.

From. The definition requires that exposures, public health effects, and environmental effects be "from" emissions and discharges. In other words, there must be a causal relationship between emissions and discharges on the one hand, and exposures, public health effects, and environmental effects on the other.

Sensitivity refers to differences in biological response; it is different from and independent of the intensity or duration of exposure. But not all biological differences in effect are evidence of sensitivity; to infer that they are denies the existence of confounders and chance. Moreover, most people are likely to be above average on some biological margin. If a large enough number of biological margins is considered, a majority of people could be deemed "sensitive" with respect to at least one of them. Of course, if everyone

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[41] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2010), vii. The Draft Report also uses this definition. See California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 3.

were "sensitive" in some respect, then as a practical matter no one would be. For this reason, even though sensitivity can be defined scientifically, a "sensitive population" cannot. It can be informed by science, but the decision of who is in and who is out can be made only by Agency officials exercising policy judgment.

The term *socioeconomic factors*, and the determination of when they are "applicable" and when they are not, is inherently ambiguous and non-scientific. Like the definition of sensitive populations, it is strictly a matter of policy judgment. Science and economics may be useful for informing this judgment, but all measures of risk could be orthogonal to the decision maker's choice of which socioeconomic factors "apply," and when.

The definition requires CalEnviroScreen to "take account" of sensitive populations and socioeconomic factors (where applicable), but it provides no guidance concerning what this means, or when it is applicable. The definition permits a host of interpretations, with little in the way of boundaries. [42]

Most Proposed Indicators Cannot Be Reconciled with the Definition of "Cumulative Impacts"

Several aspects of the proposed tool appear to conflict with the definition. The model assembles exposures, public health effects, and environmental effects as three independent components of "pollution burden." However, several of the indicators do not appear to qualify.

Some proposed exposure indicators do not measure exposure.

Two air pollution indicators—ozone and fine particulate matter—clearly qualify as indicators of human exposure to emissions or discharges. However, as the Draft Report acknowledges, neither pesticide use nor TRI releases is a bona fide indicator of human exposure. The Report justifies the inclusion of pesticide use on the ground that it "can serve as an indicator of potential burden" because "pesticide use represents an environmental release that can potentially result in human exposures."[43] The Draft Report similarly asserts with respect to TRI releases that "data on the release of pollutants into the environment is [sic] available and may provide some relevant evidence for potential subsequent exposures."[44]

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[42] Science has a role to play in establishing a rational basis for the exercise of policy judgment. For example, if an Agency official deemed a specific group a "sensitive population" or vulnerable due to "socioeconomic factors," but science could not show that the group was likely to experience disproportionate effects, such a decision might be interpreted as arbitrary and capricious.

[43] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 16.

[44] Ibid., 18.

These indicators require vast conceptual leaps to approximate any scientific definition of exposure, and unsurprisingly they lack any exposure metric. At best, they capture potential risk under exposure circumstances that are unlikely or hypothetical. This conflicts with the CI definition, which gives no weight at all to hazard, or to potential or hypothetical exposure. Moreover, it is simply impossible for public health and environmental effects to be "from" (i.e., caused by) potential or hypothetical exposures.

Traffic density presents a somewhat different problem. According to the Draft Report, it is proposed to be included as an indicator because "[e]xhaust from vehicles contains a large number of toxic chemicals, including nitrogen oxides, carbon monoxide, benzene, and particulate matter," thus giving it "a role in the formation of photochemical smog."[45] If so, then it is intended to be an indicator that is highly correlated with ozone or fine particulate matter.[46] But the available evidence shows that traffic density is weakly and non-significantly correlated. A correlation analysis performed by OEHHA staff on a sample of 30 Zip Codes yielded correlations of 0.12 with fine PM and -0.21 with ozone.[47] Therefore, while OEHHA may intend for traffic density to be a proxy for air pollution, apparently it doesn't perform that role very well.[48]

Several participants in the Academic Workshop thought that traffic density ought to be retained, but as a proxy for some other, non-air quality environmental effect, such as noise. This creates an obvious problem. It is scientifically indefensible to include an indicator and decide after the fact what it is supposed to measure. As for noise, as long as Zip Codes are used as the geographic unit of analysis, it is impossible for traffic density to be an effective proxy. There are simply no circumstances in which traffic density on any single highway could be responsible for making an entire Zip Code noisy.

Some proposed public health indictors do not measure human health effects solely or predominantly caused by pollution.

Public health effects means human morbidity or mortality from (i.e., caused by) exposure to emissions and discharges of pollutants. But the public health indicators proposed in the Draft Report do not concern human health effects demonstrably caused by exposure to pollution. Pollution is at worst a very minor contributor to aggregate incidence of the specified conditions.

Low birth weight has several causes, but pollution does not appear to be a significant one. The Draft Report implicitly recognizes this, saying that it is proposed for inclusion because there may be "racial/ethnic and socioeconomic disparities in perinatal

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[45] Ibid., 20.

[46] Indeed, when traffic density is combined with these two criteria air pollutants, the suite of exposure indicators consists of three exposure indicators, plus two non-exposure indicators that add only noise to the exposure component of the model.

[47] August, Faust, Cushing, Zeise and Alexeeff (2012), 3080.

[48] It is possible that traffic density is actually highly and positively correlated with ozone, fine particulate matter, or both, but that the use of Zip Codes as the unit of geographical analysis lacks the proper resolution to measure it.

outcomes like low birth weight."[49] Those differences have many causes, and it is scientifically inappropriate to blithely assume that pollution is the dominant one. It is especially problematic when the scientific literature consistently emphasizes other factors, notably maternal age at conception and multiple births.

Chronic conditions such as asthma, heart disease and cancer also have various etiologies, but the proportion that is caused by emissions and discharges is understood to be small.[50] Heart disease and cancer are both highly correlated with advanced age, a fact that OEHHA staff mischaracterizes in their published application of the model to 30 Zip Codes.[51]

Including these particular indicators of public health effects from emissions and releases undermines the utility of the screening tool. None of these health effects is predominantly caused by pollution, so the public health effects component of the model is essentially a random variable, uncorrelated with emissions and releases and thus impossible to reconcile with the definition of cumulative effects.

Some proposed environmental effects indicators do not measure environmental impacts solely or predominantly caused by pollution.

In a similar way, the proposed indicators of environmental effects do not actually measure environmental *effects*. Rather, they reflect the regulatory status of certain land uses. How regulatory status constitutes an environmental effect, much less evidence of "pollution burden," is not explained in the Draft Report.

Ironically, these indicators give weight to the subclass of land uses that are subject to the most stringent environmental controls. It's as if federal and state environmental regulations have no effect on public health or environmental impact.

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[49] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 30.

[50] If the asthma indicator were limited to children, a stronger case might be made for inclusion as a public health indicator. Of course, childhood asthma has many causes, not all of them environmental as that term is conventionally understood, including numerous indoor and outdoor allergens. A larger problem is that at the same time ambient air pollution is falling, asthma incidence is reported to be rising. See Akinbami, et al. (2012).

[51] OEHHA staff state that cancer and heart disease are one of the two "most strongly correlated indicator pairs," with a correlation of 0.72. They neglect to mention that this correlation is the result of confounding. Cancer and heart disease are both highly correlated with age in their sample (0.73 and 0.77, respectively). They report these facts in their table of correlation coefficients, but in the text mention only the spurious correlation with each other. See August, Faust, Cushing, Zeise and Alexeeff (2012), 3078. 3080.

Weak Causation Undermines the Proposed Screening Tool's Validity and Reliability by Adding More Noise than Signal, and Probably Injecting Bias

The CI definition requires public health to be "from" (i.e., caused by) cumulative emissions and discharges. In lieu of causality, however, OEHHA proposes a much weaker evidentiary standard. To be included, a public health indicator need only be "influenced by pollutants,"[52] an evidentiary standard of unparalleled elasticity.[53]

A review of the CI Report and Draft Report reveals a litany of terms used in lieu of causation to describe the proposed relationship between an emission or discharge and a public health or environmental effect. These terms include:

- Influenced by
- Linked to
- Associated with
- Shown to
- Can develop
- Can have [harmful] effects
- Can affect
- Suggests
- Can lead to
- May occur
- Potentially

At best, each of these verbal relations implies weak causation. In some cases, the purported causal link is conditional on, among other things, hypothetical future events.[54] The inclusion of public health and environmental effects indicators with weak, negligible, or nonexistent causal relationships undermines the utility of the proposed EJ screening tool utility for both screening and decision-making purposes. Weak causation builds into the model so much randomness that a high rate of false positives (and perhaps false negatives) is inevitable. False positives give non-EJ communities higher scores than is scientifically justified or likely to be intended by policy makers; false negatives give bona fide EJ communities lower scores than they ought to receive. Both types of error drain resources away from bona fide EJ communities in favor of non-EJ communities.

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[52] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012a), Slide 5.

[53] The CI definition requires environmental effects to meet the same evidentiary standard as human health effects—they must be "from" (i.e., caused by) emissions and releases. "Influenced by" is immeasurably weaker than "caused by."

[54] The actual scientific weight of evidence for causation is ignored here, but it begs the question whether OEHHA ought to first articulate a scientific weight of evidence framework.

Overly broad definitions of sensitive populations have adverse effects on the validity and reliability of an EJ screening tool similar to indicators with weak causation.

As long as the term *sensitive populations* is restricted to demonstrated "biological traits" that result in an observable increase in public health or environmental effects, the inclusion of such indicators skews scores in ways that appear to be consistent with officials' intended policy. However, the Draft Report uses the term *sensitive population* broadly to include "populations with biological traits that *may* magnify the effects of pollutant exposures."[55] Actual, speculative, and hypothetical sensitivity get equal weight.

This undermines the ability of CalEnviroScreen to capture what policy officials apparently intend. As in the case of weak associations between exposure and public health and environmental effects, an overly broad definition of sensitive populations increases false positives and false negatives. Some non-EJ communities will receive higher scores, and some bona fide EJ communities will receive lower scores, than is appropriate given the intended effect of applying this policy layer. The true variation in scores will be attenuated at the worst possible place—the tails of the distribution of composite scores. The attenuation will be more severe the greater is the weight given to weak claimants for the designation of *sensitive population*.[56]

Overly broad definitions of socioeconomic indicators have adverse effects on the validity and reliability an EJ screening tool similar to indicators with weak causation.

Taking OEHHA's geographical approach at face value, "socioeconomic factors" are "community characteristics that result in increased vulnerability."[57] This dependent clause is another way of describing causal relationships—in this case, between the indicators and conditions that lead to increased vulnerability to pollution. Under that logic, only indicators that demonstrably increase vulnerability should be eligible for inclusion.

If community characteristics that do not increase vulnerability are included, and vulnerability is given multiplicative weight, then composite scores will be biased toward the middle of the distribution, reducing scores for bona fide EJ communities and increasing scores for non-EJ communities. Because the suite of socioeconomic factors is multiplied, these biases toward the mean will be even more severe, resulting in composite scores that are more misleading.

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[55] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 7; emphasis added.

[56] In particular, multiplying exposure, public heath effects, and environmental effects by overly broad indicator(s) for sensitive populations will cause more harm to model outputs than adding the indicator values. Multiplication magnifies errors just as easily as it magnifies effects that are intended.

[57] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 7.

Problems with the Geographic Approach

The cliché that a picture is worth a thousand words, and among the various types of pictures that can be constructed, maps are among the most appealing. Thus it comes as no surprise that OEHHA would settle on a geographic representation of its EJ scoring system. Nonetheless, a geographic backbone for an EJ scoring system has several important undesirable features.[58]

Geographic Assignment Implies that Environmental Justice Is About Places, not People

The underlying theme of the EJ literature is environmental inequity with respect to people, and communities of people. To the extent that people are relatively immobile and live most or all of their lives within the same geographic unit, there is no harm in using geography as a shorthand way to characterize them.

Still, it is important to keep in mind that geography is only a proxy for people, and its utility as a proxy depends on them staying in the same place. If people are mobile across geographical boundaries of interest, or if their lives are improved by relocating, geography becomes a poor proxy and no longer represents them well. For this reason, a geography-based model that is insensitive to residential tenure will misrepresent the target population.

In a similar vein, a geographic model based on residential location ignores the extent to which members of a target population may be highly mobile even if residentially stable. To take the most obvious example, the use of residential geography to characterize exposures, public health, and environmental effects ignores the extent to which exposure occurs elsewhere. Not only does the geographic model assume that people live in the same place all their lives, it also assumes that they work, shop, and play there, too.

A Forced One-Size-Fits-All Geographic Model Leads to a Lot of Bad Fits

The larger the geographic unit used as the basis for constructing the scoring system, the greater will be its propensity to discard variation within each geographic unit. OEHHA appears to be using a Goldilocks approach to intuit the "right" one-size-fits-all geographic scale—one that is "not too large" and "not too small."[59]

This approach implicitly makes two dubious assumptions. First, it assumes that the ideal is some sort of "grand mean" design even though, as noted above, the use of averages inherently suppresses variation that policy officials might regard as essential to retain to give the scoring system practical utility for decision-making. Second, it assumes that every

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[58] In this discussion, it is assumed that EJ designation is desirable for the purpose of demonstrating eligibility for certain specified benefits. It seems unlikely that policy officials would have ordered the tool to be developed for the purpose of imposing costs on EJ-designated communities, thus making the lives of their residents worse.

[59] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012a), Slide 8.

indicator that ought to be in the scoring system must have the same level of geographic precision. For valid indicators that have less geographic resolution, OEHHA proposes to interpolate average values for smaller geographic units. Indicators that have more resolution may be averaged to obtain the grand mean for the unit of resolution selected. Both practices increase uncertainty and add error.

Geographic Assignment Rewards and Incentivizes Residential Segregation

Any scoring system that relies on geography gives greater weight to units in which people who experience or display the relevant characteristic are highly concentrated. Conversely, the more dispersed these people are, the lower will be the score given to the geographic unit in which they reside.

To sustain a high EJ score, residents of a geographically defined community must preserve their geographic identity. Unfortunately, this means sustaining (perhaps even cultivating) the same, presumably undesirable characteristics that enabled their original high score. But sustaining concentration also means rewarding and incentivizing perpetual segregation. Any effort to integrate people who differ across any one of the indicators used in the scoring system will have the effect of flattening community scores. Unless communities are scored exactly once, that could result in a loss of benefits associated with programs to remedy EJ concerns.

Problems Associated with Misusing a Screening Tool for Decision Making Purposes

The Draft Report repeatedly characterizes CalEnviroScreen as a "screening tool," most obviously but not exclusively by its name. However, there are several places in the Draft Report or in supporting documents where it is clear that Cal/EPA intends to use the tool for guiding or controlling regulatory decision-making. The Draft Report includes a constraint on regulatory use, but that constraint is temporary.[60] The CI Report includes a similarly limited caveat.[61] In briefing materials provided at the Academic Workshop, OEHHA says that "[p]ollution burden indicators should related to issues that may be actionable by OEHHA,"[62] a sure indicator of the Office's intent to use the tool for regulatory

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[60] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), Preface 2: "No regulatory or policy decisions should be made <u>based on the preliminary results</u> in this document" (emphasis added).

[61] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2010), iii: "Cal/EPA intends shortly to initiate the development of guidelines to accompany this methodology. <u>Until these guidelines are completed</u>, the scientific screening methodology discussed in this report is not to be used for regulatory purposes, including the permitting of facilities or compliance with the California Environmental Quality Act" (emphasis added).

[62] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012a), Slide 10.

intent. Thus, it is clear that, once the bugs have been worked out, OEHHA intends to use this *screenin*g tool to guide or control regulatory *decisions*.

The correct use of a screening tool is just that—to *screen* an array of items to determine which among them warrant more intensive review or examination, and which do not. In medicine, screening tools are used in differential diagnosis to exclude from further consideration conditions that can be effectively ruled out. Good screening tools have low false negative rates—that is, they are highly unlikely to lead a physician to exclude a diagnosis that later could turn out to be correct. There is a cost involved, of course, in that screening tools often have high false positive rates—that is, they suggest diagnoses that will turn out not to be correct. The medical community has become increasingly concerned that its screening tools have too many false positives, thus leading to much unnecessary medical intervention and patient anguish. For example, the National Cancer Institute says that mammography detects about 90% of breast cancers, but it has a positive predictive value of just 6-8%, depending on a woman's age.[63] This means the vast majority of "positive" mammography reports do not show cancer, even though that is exactly how women interpret positive results.

In environmental protection, numerous screening tools are used to determine whether further research, investigation, or risk assessment is justified. But these tools are intended to rationally allocate scarce investigative resources, not as substitute for more detailed, often site-specific investigations. Environmental agencies also perform safety assessments, which have similar characteristics. They are intended to determine an upper-bound exposure or dose that policy officials can deem to be "safe," and thus below regulatory concern. These tools do not produce any actionable information about risk, for the estimation of dose-response is beyond their scope.[64] Thus, when properly applied, a screening tool reveals which circumstances and scenarios deserve no further analysis, but it never purports to reveal which circumstances and scenarios deserve regulatory intervention, much less how much.

OEHHA's proposed EJ screening tool is intended to do what a screening tool cannot—inform decision-makers as to which communities deserve some sort of intervention to alleviate cumulative impacts. But CalEnviroScreen is not a bona fide decision tool because it lacks the information quality characteristics that decision tools must have. In particular, CalEnviroScreen lacks the capacity to discern true from false positives and the distinctions it makes among communities are more arbitrary than informative. Decision tools that produce arbitrary results lack a reasoned legal basis.

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[63] National Cancer Institute (2012).

[64] For example, OEHHA defines the Reference Exposure Level (REL) as "[t]he concentration, at or below which no adverse health effects are anticipated in the general human population." The definition says nothing about risk or dose-response for any exposure or dose exceeding the REL. In short, the REL is a regulatory policy screening tool "designed to protect the most sensitive individuals in the population by the inclusion of margins of safety."

Further, the proposed EJ screening tool would create an adversarial environment in which communities with the highest scores would expect to be allocated greater resources, regardless of whether intercommunity differences are meaningful, artifactual, or arbitrary. Conversely, communities seeking resources but with lower scores can be expected to complain that the tool produces arbitrary results and thus lacks legitimacy.[65] That OEHHA specifically declines to commit to use its proposed screening tool only as a screening tool[66] will greatly exacerbate intercommunity conflict, leading many to infer bad faith.

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[65] Communities that believe they have been stigmatized by an illegitimately high score also will contest their scores and the scoring tool.

[66] See California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 1, explicitly rejecting any Office responsibility to use CalEnviroScreen for screening, its stated purpose: "[T]he screening tool is not intended to create a legal obligation to conduct additional detailed cumulative analyses for the staff reports written for individual rulemaking." It is to guide the production of detailed analyses, not decisions, that screening tools are specifically intended for.

PART 3: A REVIEW OF THE PROPOSED INDICATORS

Previously, several conceptual issues common to any EJ screening tool were addressed in considerable detail. In this section, the proposed indicators are examined specifically. Four particular issues are considered:

1. Is the indicator conceptually consistent with the CI definition and the purposes of EJ screening?
2. Does the indicator actually measure (or provide a credible proxy for) the phenomenon of interest?
3. Would the indicator as proposed advance the stated policy goals of ensuring a high quality screen for the effects enumerated in the CI definition?
4. Are there other potential indicators that could be better suited for the purpose of EJ screening?

First, however, it is necessary to identify several generic quality standards that ought to be met by every indicator.

Minimum Quality Standards for Indicator Selection

For an EJ screening tool to have scientific merit and deserve public credibility, each indicator considered for inclusion should meet certain minimum quality standards.

Indicator Data, Model Inputs, and All Code Necessary to Reproduce Model Outputs Must be Made Available to the Public

Transparency requires that indicator data be publicly available. Data need not be *public* data, provided that private data owners are willing to make them publicly available at a reasonable cost.[67] The crucial thing is that data must not be confidential because secrecy is inconsistent with the public's reasonable expectation of being able to reproduce results, validate (or refute) data quality assumptions, and test the effects of alternative assumptions, data, and model specifications.

Reproducibility is essential for any EJ screening tool to deserve public credibility. Just as indicator data must be publicly available, so must be the model and all computer code necessary to reproduce model outputs. Reproducibility is not a peculiar interest of industry. Local public officials and residents of prospective EJ communities also must be able to reproduce community scores, uncover data errors, and evaluate the effects of alternative indicators and model specifications. If important details of the model are not disclosed, or they are disclosed but made difficult to access, public support for the

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[67] Government data sets often are difficult to use effectively, creating an opportunity for private entities to create value-added versions that make access and use easier. The proper way to think about data access is in terms of the full cost of acquisition, management and use. Popular private value-added versions will tend to have lower total costs; otherwise, there would be no market demand for their products.

screening tool will be unnecessarily limited and the Agency will be subjected to public distrust.[68]

Indicators Should Be Objectively Defined

Each indicator should have an observable value. Indicators whose values are defined by the application of policy judgment cannot be justified scientifically, for science cannot resolve policy choices. Equally important, indicators controlled by policy choices are unlikely to garner the public support they need unless the policy judgments embedded within them are obvious, universally shared, and cannot be satisfied by an alternative indicator. Otherwise, controversies can be expected concerning how policy judgments were applied.

Even if the policy judgments embedded in a subjectively defined indicator are uncontroversial, it is likely that many alternative indicators could be devised to implement these judgments. Each alternative indicator would score the phenomenon of interest differently, and scoring differences at the margin could be crucial.

In the Draft Report, five proposed indicators stand out as problematic because they are subjectively defined by OEHHA:

- Pesticide Use
- Cleanup Sites
- Leaking Underground Storage Tanks
- Permitted Solid Waste and Hazardous Waste Facilities
- Population Sensitivity Due to Age

In each case, even if it is stipulated that the indicator measures in principle exactly what ought to be measured, the weights proposed for assignment by Agency staff are subjective and easily disputed. Many other weighting schemes could be devised, each one having different effects on the scoring system. Composite scores are unreliable to the extent that they are materially affected by these subjectively determined indicator values. Whether they have a material effect cannot be discerned by any member of the public, however, because OEHHA has not disclosed the tool or its outputs.

Data Must Have Quality Attributes Appropriate for Use in EJ Screening

Data are obtained for a variety of reasons ranging from demographic characterization to exploratory data analysis to internal agency management to regulatory enforcement. The purpose for which a data set was collected must be carefully researched before it is considered for use as an indicator. This review must examine the data's

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[68] In my presentation before the Academic Panel on September 7, I displayed reproductions of maps published in the Draft Report that appeared to show "hot spots" in cancer mortality in the Los Angeles area. OEHHA staff subsequently acknowledged that they were aware of these apparent hot spots but said they were artifacts of printing. This misunderstanding would have been avoided if OEHHA had publicly disclosed its output data prior to the Workshop.

accuracy, precision, and reliability, and be sensitive to its inherent imitations. It is a substandard research practice to obtain and use third-party data without regard for their quality and original purpose.

Only after these reviews are completed is it appropriate to consider a data set for inclusion as an indicator. A second examination should focus on whether the data meet the quality standards established for the intended derivative application.[69] High quality standards are appropriate regardless of what the EJ scoring system is intended to do; they are essential if it is going to be used for regulatory purposes. It is not appropriate for OEHHA to assume that a data set meets its needs just because it may have met someone else's and is readily available.

A special problem for any EJ scoring system is that it seeks to obtain fine resolution at the upper tail of the distribution of each indicator and the composite score. Estimating the tails of distributions is inherently much more difficult than estimating central tendency. However narrow might be the lower and upper 95th confidence intervals on estimates of the mean, what OEHHA needs is narrow confidence intervals on estimates of the 95th percentiles of each indicator and of the composite score. That requires a data quality design in which the upper tail of each indicator has been oversampled to improve accuracy.

This data quality objective can be finessed if the screening tool is used just for screening—that is, determining which geographic units warrant no additional research. But if the tool is used to inform decision-making, as the Draft Report and supporting documents make clear is the intent, then only the most stringent of data quality standards would be minimally sufficient.

Imprecision, Inaccuracy, Bias, Uncertainties, and Limitations in the Original Data Must Be Preserved and Correctly Propagated by the Model

Whatever imprecision, inaccuracy, bias, and uncertainty are found in a third-party data set, they will be reflected in, and possibly amplified by, the EJ scoring tool.[70] In the proposed model, the validity of composite scores is much more limited than suggested by the Draft Report. Users of the tool have every reason to treat composite scores as being as precise as they are reported, which is with up to three significant figures. Yet it is not clear whether any of the reportedly significant figures in fact is significant.

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[69] OEHHA has established a set of data quality objectives that are helpful (see California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 5, stating as quality attributes "complete, accurate, current"). But these attributes are not clearly defined. By "complete," OEHHA appears to mean that data sets do not have a lot of missing values (a clearly desirable data quality attribute) and the same geographic resolution (an attribute whose merits is not demonstrated). Moreover, OEHHA does not apply these data quality standards to the five subjectively constructed indicators, whose "accuracy" cannot be verified or refuted.

[70] Imprecision, inaccuracy, bias, and uncertainty are amplified if an indicator's values are added (as opposed to averaged), and amplified more if it is multiplied.

To avoid these pitfalls, the scoring system should propagate all known imprecisions, inaccuracies, biases, and uncertainties throughout the model. It is not appropriate to ignore them in the hope that "it will all average out." Such a rule might be justifiable of the purpose of the tool was to describe the middle of the distribution, but it isn't. The EJ screening tool is intended to identify the upper tail of a multicomponent distribution, which requires extraordinary attention to data quality in the very locations where uncertainty is naturally the greatest.

Indicators Must Measure Attributes of Genuine Interest and Relevance to EJ Screening

It may seem obvious, but it bears stating clearly that every indicator used in the EJ screening tool must measure (or be a high quality proxy for) the phenomenon of interest. Exposure indicators must measure actual human exposure to emissions or releases. If they do not measure exposure, they are incompatible with OEHHA's definition of cumulative impacts, and there is no rational basis for including them in the model. It is especially troubling when a purported indicator of exposure actually measures, at best, *potential* exposure occurring under *hypothetical* conditions. This gives equal weight to real and hypothetical human health risk, and biases the screening tool against those persons who are actually exposed and really are at risk.

Similarly, public health indicators should measure health effects solely or predominantly caused by human exposure to emissions or releases. The inclusion of indicators that have only a limited or speculative environmental component adds mostly noise to the scoring system and biases scores toward the mean. Likewise, environmental effects indicators should measure environmental effects solely or predominantly caused by emissions or releases. If they do not, then they impart bias, noise, or both to the screening tool.

Proposed Exposure indicators

The proposed screening tool has five exposure indicators. Two of them measure exposure and two others do not. The remaining indicator could be a proxy for exposure, and there seems to be a debate about what to do with it.

Proposed Exposure Indictors that Measure Exposure

There are two indicators in this set: ozone and fine particulate matter, and a third that is promoted in the Draft Report as being a proxy for air pollution.

Ozone and fine particulate matter

These are well-established indicators of exposure to ambient air pollution. They are less useful as indicators of indoor air pollution, however, and this is important if the final scoring tool (as proposed) gives multiplicative weight to communities with disproportionate numbers of elderly residents. On average, the elderly spend more time

indoors at home than other age groups, and among the elderly those in the poorest health (and thus the most vulnerable) are especially likely to stay indoors.[71]

For ozone, OEHHA proposes to use the daily maximum 8-hour ozone concentrations for the summer season (May-October), averaged over three years (2007-2009). For fine PM, OEHHA proposes to use the average of quarterly mean concentrations over three years (2007-2009). While each of these indicator designs is plausible, there are many others that could have been chosen instead, and the Draft Report does not give any reasons why these indicators were preferred.

Choosing the best of the potential indicators requires thinking clearly about which ones do the best job at measuring EJ impacts, not just air pollution generally. For example, a plausible EJ interpretation of air pollution might take account of both ambient concentrations and emissions in each geographic unit. Geographic units that are net contributors to air pollution might get lower scores than geographic units that contribute relatively little to what they experience. Perceptions of environmental inequity may be related to the extent that a community bears a share of metropolitan or regional pollution that is a disproportionate to its relative contribution.[72]

In contrast, the proposed air pollution indicators give no weight to where emissions come from. They do not take account of the extent to which each geographic unit is a net contributor to regional air pollution. With this interpretation of environmental inequity in mind, mobile source emission shares might be assigned to the geographic unit of origin rather than the Zip Code in which they are measured.

Traffic density?

The Draft Report proposes to include traffic density because mobile sources emit "a large number of toxic chemicals, including nitrogen oxides, carbon monoxide, benzene, and particulate matter."[73] Particulate matter and nitrogen oxides are already explicitly or implicitly included as indicators, however, and it appears that traffic density is only weakly correlated with both ozone and fine PM.[74]

At the Academic Workshop, it was revealed that Agency staff had considered outputs from USEPA's National-Scale Air Toxics Assessment (NATA) but decided against it.

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[71] USEPA recommends that risk assessors assume that the average amount of time spent indoors at home is 1,175 minutes (19.6 hours) per day for those 65 years of age or older. The 95th percentile is estimated to be 1,440 minutes (24 hours) per day. See U.S. Environmental Protection Agency (2011a), xxii. How much they are actually exposed to ambient air pollution is uncertain.

[72] This notion is based on a reasonable interpretation of fairness as the absence of net environmental externalities. A community whose own emissions are less than proportional to its exposure could be viewed as experiencing an environmental inequity.

[73] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 20.

[74] August, Faust, Cushing, Zeise and Alexeeff (2012), 3080.

Thus, it is reasonable to infer that the Agency might be trying to find an exposure indicator for other environmental pollutants and effects such as black carbon, traffic noise, and psychological stress.[75] If so, then the decision to use Zip Codes as the geographic unit of analysis creates a problem because it is too coarse. Exposures decline exponentially with distance from major highways, and the vast majority of residents in a zip code containing such a highway may not be exposed at all.

If traffic density is intended to measure some other exposure attribute, however, then a lot more careful thought is needed about exactly what the indicator is intended to measure. It is not legitimate to put an indicator into the model, and then after the fact decide what it's there for.[76]

Proposed Exposure Indictors That Do Not Measure Exposure

Two proposed exposure indicators are problematic because they do not measure exposure.

Pesticide use

Pesticide exposure could be an important indicator for an EJ scoring system. As stated in the Draft Report, "Pesticide exposure can occur by many different pathways, including drift incidents, worker exposures in the course of application, and consumption of pesticide residues in treated commodities."[77] Of these identified exposure routes, worker exposure could be the most relevant. Whether that has merit as an EJ-related indicator is open to debate, but it has much more intuitive appeal than residues. Meanwhile, the Draft Report does not mention exposures that occur due to household use (and misuse), though why this would be EJ-related also is not obvious.

Meanwhile, the proposed indicator is a hybrid of two existing databases that measure fundamentally different phenomena, neither of which is particularly useful for quantifying human exposure. The proposed indicator—pounds of selected active pesticide ingredient use per square mile, including both agricultural and non-agricultural uses—is merely mass per unit of area. Mass is not an adequate proxy for exposure, and mass per unit of area is no better.

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[75] Researchers who have studied traffic density have found evidence that it is a better predictor of mortality risk than ambient air pollution. See Lipfert, et al. (2006).

[76] The National-Scale Air Toxics Assessments (NATA) model is problematic in its own right. Among other things, USEPA specifically warns against using NATA to "characterize or compare risks at local levels such as between neighborhoods." See U.S. Environmental Protection Agency (2012b). Furthermore, USEPA also says "results … be used cautiously, as the overall quality and uncertainties of the assessment will vary from location to location as well as from pollutant to pollutant." See U.S. Environmental Protection Agency (2010a), ICF International (2011), Chapter 7.

[77] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 16.

The Draft Report acknowledges this, saying that pesticide use is "not a true measure of exposure," but defends its inclusion nonetheless on the ground that it "can serve as an indicator of potential burden, … an environmental release that can potentially result in human exposures."[78] Neither potential exposure nor potential "burden" are appropriate substitutes for exposure in a model that purports to take exposure seriously.

This particular indicator of pesticide exposure simply cannot be justified scientifically. In addition to failing to measure exposure, it also takes no account of extensive regulations intended to minimize it. Rather, it implicitly assumes that risk-reducing regulation is immaterial to risk.

The non-production use component is not well described, and there are sound reasons for concluding that it is inappropriate for use in an EJ scoring system. First, it includes an extraordinarily broad array of uses that entail huge variations in likely exposure.[79] Second, for none of these uses is there even an attempt made to estimate exposure. Third, the data are incapable of saying anything useful about the upper tail of a (presumed) exposure distribution. Finally, each non-production use conveys a public benefit that has not been accounted for. Even if it is presumed that non-production use has adverse environmental effects on EJ communities, such use also would benefit EJ communities by reducing or eliminating environmental effects due to exposure to pests, including vermin that otherwise would infest community housing.

As noted above, a prerequisite for the use of any data set in a secondary application (such as an EJ screening tool) is that its accuracy, precision, reliability, and limitations with respect to its original intended use are understood and accounted for. For pesticide use data, it is not obvious that these data are meaningful even for their original intended purpose. They apparently are susceptible to error,[80] and they are reported with such extraordinary precision as to raise doubts about whether measurement uncertainties are retained and correctly propagated.[81]

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[78] Ibid., 20.

[79] Non-production uses are defined as agricultural and non-agricultural. The definition of agricultural uses is itself extraordinarily broad, including "applications to parks, golf courses, cemeteries, rangeland, pastures, and along roadside and railroad rights-of-way," plus "all postharvest pesticide treatments of agricultural commodities must be reported along with all pesticide treatments in poultry and fish production as well as some livestock applications" (ibid., 1616). A review of the 2010 use report for Los Angeles County (to take one example) reveals a host of uses including agricultural applications, industrial sites, plants in containers, landscape maintenance, lumber treatment, greenhouses, nurseries, structural pest control, regulatory pest control, rights-of-way treatment, sewage system operations, turf/sod treatment, uncultivated agriculture, vertebrate control, water treatment, and public health.

[80] Ibid., 16: "The validation and accuracy checking process takes some time…"

[81] Reported precision is ± 0.005 pound, or approximately 2.27 g.

Appendix A1 in the Draft Report sets forth the procedures that were used to convert the original data into the proposed EJ exposure indicator. It is understandable why OEHHA would want to devise a screening tool to eliminate low-hazard pesticides. Indeed, the elimination of items believed to be below the minimum level of concern is an appropriate use of a screening tool.[82]

However, why OEHHA also applied a screen for volatility is not well explained. Arguably such a screen would eliminate pesticides for which airborne exposure is extremely unlikely. But it is not correct to assert, as OEHHA does, that "[h]igher volatility was considered to increase the likelihood of exposures." This screen gives special weight to the air exposure pathway, and it takes no account of whether people are actually present in close enough proximity and without respiratory protection to actually be exposed.

In short, OEHHA's use of preliminary screening tools for hazard and volatility are useful insofar as they excluded pesticides that are below arbitrary but perhaps plausible boundaries for regulatory concern. That is the way screening tools should be designed. However, the application of these screens did nothing to improve the quality of the remaining data for use as an indicator of pesticide exposure, whether for EJ purposes or any other. Summing the quantities of 65 different pesticides that differ by orders of magnitude in intrinsic biological and ecological hazard also accomplished nothing scientific, and without a credible human exposure metric it would not matter even if such summation made sense.

The resulting values for pesticide *use* assigned to each geographic unit are thus uncorrelated with pesticide *exposure*, except by accident. The inclusion of this indicator adds only noise to the composite score.

TRI releases

OEHHA proposes to include total hazard-weighted pounds of reported chemicals released on-site to air or water from USEPA's Toxic Release Inventory (TRI).[83] The reason

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[82] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 66: "Specific pesticides included in the measure of pesticide use were identified from the list of all registered pesticides in use through a filter that considered both hazard *and* likelihood of exposure." According to the Draft Report, "For the purpose of developing an exposure indicator, pesticides that were prioritized as 'Low,' not prioritized under SB 950, and not on the Proposition 65 list were removed from the analysis." The full process used by OEHHA is obscure, however, described as a "subjective process based upon the nature of potential adverse effects, the number of potential adverse effects, the number of species affected, the no observable effect level (NOEL), potential human exposure, use patterns, quantity used, and US EPA evaluations and actions, among others." It does not meet minimum standards for transparency and reproducibility set forth in Section x above.

[83] The Draft Report appears to exclude disposals, but it is not completely clear on that point. Disposals are not releases to the environment with any reasonable prospect of public exposure and thus should be eliminated from further consideration.

given is "widespread concern regarding exposures to chemicals that are released from industrial facilities."[84] But TRI data cannot be a high quality indicator of human exposure because mass and exposure are not the same thing. Indeed, the only connection to exposure articulated in the Draft Report is the speculative claim that release data "may provide some relevant evidence for potential subsequent exposures." As has been noted for other proposed exposure indicators that do not measure (or even provide a credible proxy for) exposure, the inclusion of this indicator adds noise to the exposure component of the screening tool; averaging it with bona fide exposure indicators produces an index of unknown provenance, quality and meaning. Quite possibly, it adds substantial but unknown biases as well.

With this in mind, OEHHA might want to reconsider the purpose it intends TRI releases to serve in its EJ screening model. To do that, it would help to first review the accuracy, precision, reliability, and limitations of the original data.

Beginning with limitations, facilities are required to report if they employ 10 or more persons and manufacture 25,000 pounds of a covered chemical or otherwise use 10,000 pounds, with lower reporting thresholds required for chemicals classified as persistent, bioaccumulative or toxic (PBT) and dioxins or dioxin-like compounds. This means there are no TRI data for facilities smaller than these thresholds. This means the TRI data represent a subset of unknown scope of the entire array of such releases. To the extent that the TRI program has led reporting facilities to reduce their releases, a result that is widely believed to be true, these reductions are much less likely to have been achieved by facilities exempt from reporting—an obvious bias when used for EJ screening

An often overlooked limitation of TRI data arises from complications resulting from the complexity of the program, including for example the inherent imprecision in facility reports.[85] Facilities may report releases as pounds per year in integers or as a range code.[86] These range codes incorporate substantial uncertainty, as shown in Table 3 below. Range Code 06, for example, could indicate any quantity between 1 million and 10 million pounds, exclusive. Indeed, five of the 11 range codes span a factor of 10; range codes with narrower proportionate intervals still span tens to hundreds of millions of pounds. With this much inherent uncertainty, the simple task of summing releases for the *same* chemical from multiple facilities within the *same* geographic unit is mathematically complicated.[87]

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[84] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 18.

[85] The instructions for reporting on Form R, the USEPA's TRI information collection, are 190 pages long. See U.S. Environmental Protection Agency (2011b).

[86] Ibid., 44.

[87] The proper way to sum bounded uncertain quantities is with interval arithmetic. The bounds of a sum of two interval values are the lower and upper bounds of all possible values in the sum. For a simplified exposition, see the Wikipedia entry at http://en.wikipedia.org/wiki/Interval_arithmetic. The Draft Report is not clear concerning how interval values were summed. USEPA typically reports midpoints in lieu of the entire

Table 3: TRI Range Codes

Range Code	Minimum (pounds)	Maximum (pounds)	Range Span
01	0	99	∞
02	100	999	10
03	1,000	9,999	10
04	10,000	99,999	10
05	100,000	999,999	10
06	1,000,000	9,999,999	10
07	10,000,000	49,999,999	5
08	50,000,000	99,999,999	2
09	100,000,000	499,999,999	5
10	500,000,000	999,999,999	2
11	1,000,000,000	> 1,000,000,000	∞

Actual releases may not even be within the reported interval. Facilities are directed to base their reports "on the level of accuracy that their data supports"[88] derived from "readily available data (including monitoring data) collected pursuant to other provisions of law, or, where such data are not readily available."[89] It may be convenient for users to treat "best available data" as precise, but this is incorrect when the both law and regulation authorizing the information collection do not require or assume precision.

Even if TRI releases were known with certainty, summing them would not yield a valid measure of human exposure. Yet OEHHA proposes to go even further by using transformed values obtained from the application of USEPA's hazard-weighted Risk-Screening Environmental Indicator (RSEI). This tool is said to reduce one form of uncertainty (variations in inherent chemical hazard), but its outputs are valid only if several conditions are met, including the absence of bias in toxicity weights, an assumption

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interval, thus discarding the uncertainty contained in range reporting and generating substantial errors.

[88] U.S. Environmental Protection Agency (2011b), 67.

[89] Ibid., 48.

that by design does not hold.[90] Exposure also is not accounted for, so it might be suggested that OEHHA use USEPA's risk-related RSEI model instead. However, this version of the model also cannot produce unbiased results because toxicity values are biased.

Finally, it is worth noting that OEHHA's proposed use of RSEI-weighted TRI releases is not consistent with universally recognized limitations of the tool. USEPA advises that RSEI scores be used only for screening or ranking at relatively high degrees of geographic aggregation, such as regions, states, and counties.[91] Even though disaggregation to Zip Codes is known to be invalid, that is exactly what OEHHA proposes to do.[92]

Public Health indicators

Similar problems bedevil the proposed indicators of public health effects. As noted above, at least three of the four proposed public health effects are weakly correlated or not correlated at all with emissions and releases. This means they are inconsistent with the definition of *cumulative impacts*, with which any EJ screening tool must comply.

The specific indicators proposed are even more problematic. They are poor proxies for the public health effect they are supposed to represent. The proposed asthma indicator does not focus on children, for which aggregate asthma incidence is least implausibly environmental in origin. The indicator for low birth weight is likely to be negatively correlated with environmental inequity. Cancer and heart disease mortality cannot reasonably be assigned to the Zip Code of residence at death.

Proportion of infants with low birth weight

The Draft Report proposes to include as an indicator of a public health effect low infant birth weight (LBW, < 2500 g), measured as the five-year average low birth weight rate (2005-2009).[93] However, the justification for this indicator focuses on what are most charitably described as socioeconomic factors that might predispose some residents in EJ

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[90] See Bouwes and Hassur (1997), 29 ("Pathway-specific overall toxicity weights are based on the single most sensitive health endpoint [i.e., highest toxicity weight] observed without applying additional weights for the severity of the health endpoint or the number of observed effects.") and U.S. Environmental Protection Agency (2010b). RSEI weights are intended to be public-health protective, and thus they are not unbiased. Moreover, because the amount of bias varies across toxicity weights, the application of any arithmetic operator yields biased results.

[91] See U.S. Environmental Protection Agency (2012a): "Note that detailed, local results involve the most uncertainty as a result of small sample size. All RSEI results should be followed up with additional analysis if detailed conclusions are desired."

[92] The proposed indicator is "Total hazard-weighted pounds of chemicals released on-site to air or water from all facilities within the ZIP code, or within one kilometer of the ZIP code" (emphasis added). See California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 19.

[93] Ibid., 30.

communities to deliver LBW babies. The text makes only tangential, weak claims about the relationship between pollution and LBW, and even these claims are qualified by reference to socioeconomic factors.[94]

Whenever an indicator is included whose association with pollution is weak or tenuous, it will have the undesirable effect of causing classification error and biasing scores toward the mean. All other factors held constant, bona fide EJ communities will receive lower scores than they should, and non-EJ communities will receive higher scores.

Classification error can be expected to be especially pernicious because the proposed indicator is likely to be *negatively* correlated with EJ. The strongest contributors to LBW are maternal age (both very young and very old), plural births, and the use of assisted reproductive technology.[95] With the exception of births to teens, which has been declining, each of these factors is highly correlated with income, and with each other.

Focusing on age first, Figure D plots data from the California Department of Health showing that LBW in California is concentrated among older mothers. (The red line shows the statewide average independent of age.) This is consistent with data reported by the federal Centers for Disease Control showing that births to teens is declining, whereas plural and assisted reproductive technology births are rising, the latter being concentrated among older women.

Looking now at income, Figure E reproduces the map published in the Draft Report showing that many communities intuitively understood to have high average incomes also tend to be in the highest deciles for LBW. There is already a concern that any indicator for LBW adds noise rather than signal to communities; composite EJ scores. Unless the indicator is very carefully redesigned and reconstructed, its inclusion also will inject bias by increasing the scores of relatively wealthy communities where women more often

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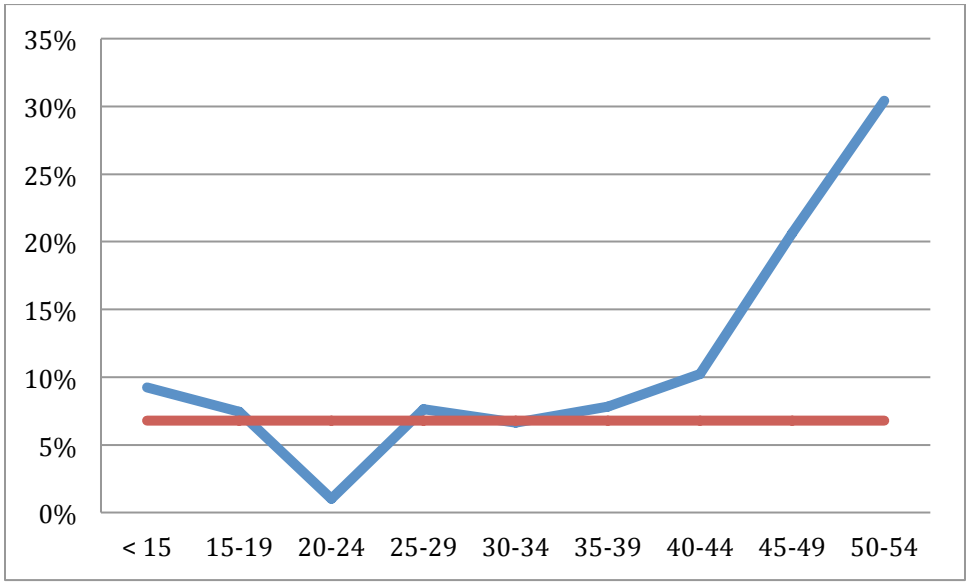
[94] Ibid., 30: "Research has shown a link between low birth weight and environmental hazards like air pollution." The scientific basis for this statement is found in the CI Report, which cites a single study reporting associations between a number of criteria air pollutants and birth weight declines ranging from 8.9 g to 16.2 g—0.4% to 0.6% of the threshold for low birth weight (2,500 g), an effect size that is biologically meaningless. See California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2010), 13, 23.

[95] Martin, et al. (2005), 19: "In 2003 mothers under 15 years and mothers over 45 years of age were two to three times as likely to bear a VLBW [very low birth weight] infant compared with their 25–34-year-old counterparts. Any analysis of LBW or VLBW risk by maternal age, however, should take into account the disproportionate impact of multiple births on levels for older women. Plural births are much more likely to be LBW and VLBW and also occur much more frequently among older women. In illustration, among all infants born to women 45 years and over in 2003, the VLBW rate was 4.0 percent, twice the VLBW level for singletons born to this age group (2.0 percent)" (internal cross references omitted).

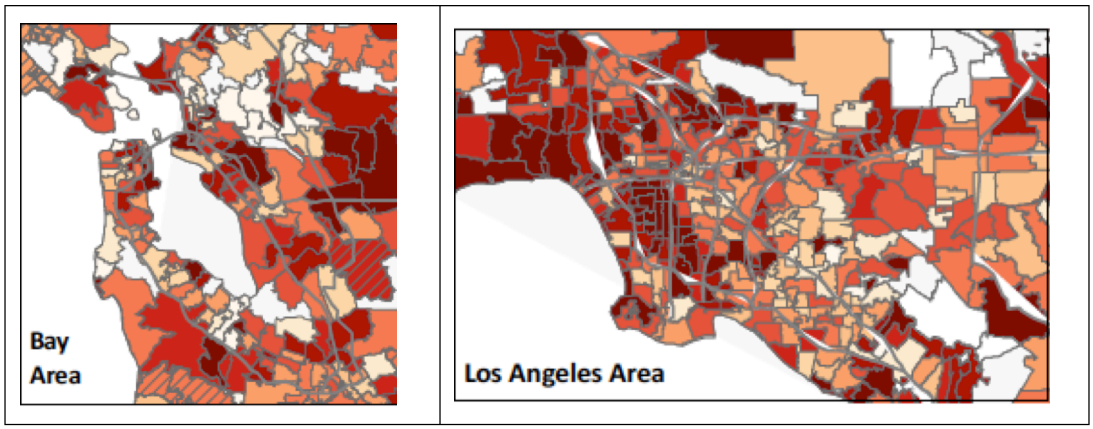
choose to delay childbearing or, because of advanced age, require assisted reproductive technology to conceive.

Figure D: Low Birth Weight by Maternal Age (California Counties), 2010



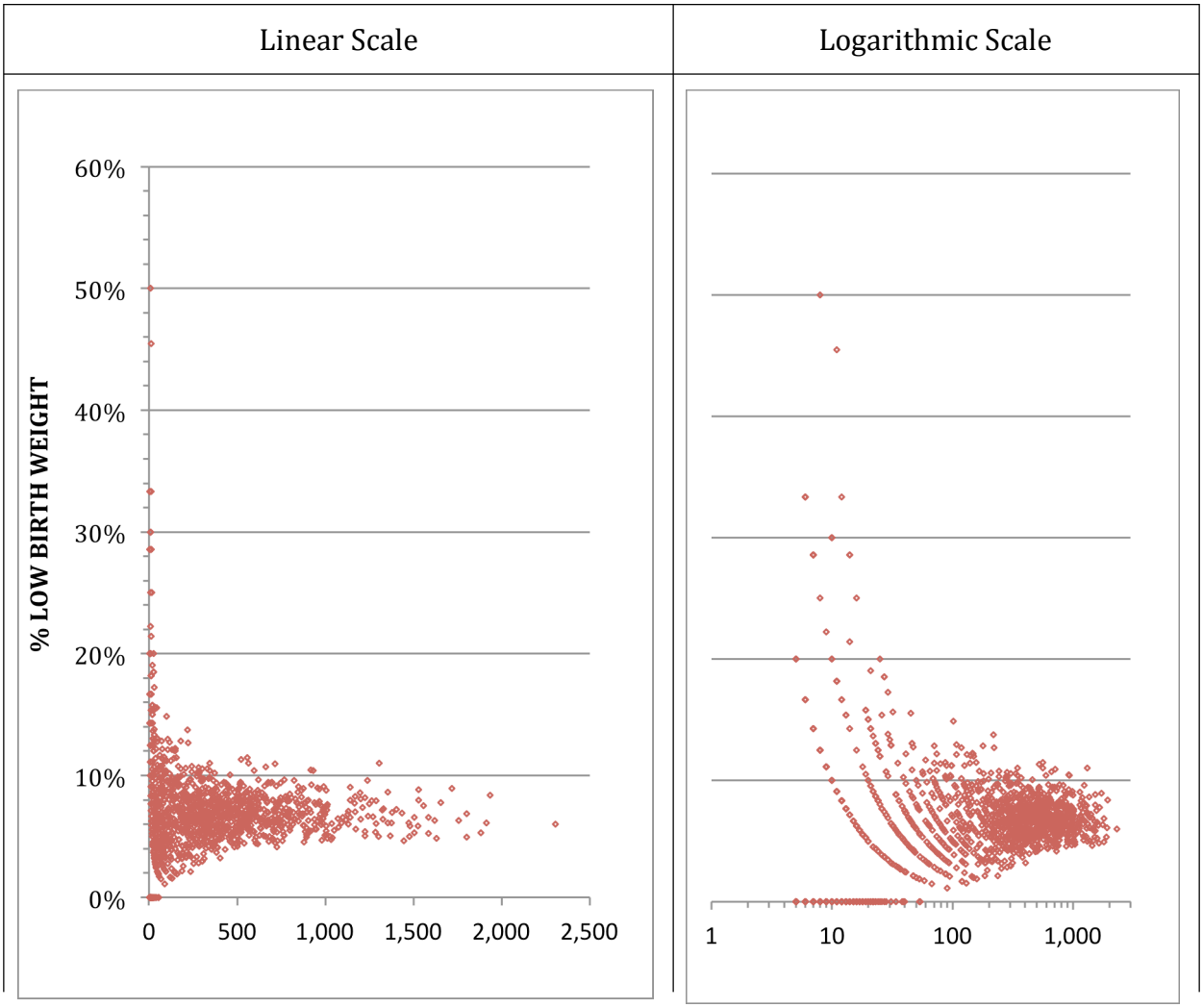
The particular indicator proposed by OEHHA—the *rate* of LBW by Zip Code—is susceptible to another form of systematic error. As noted above, Zip Codes vary greatly in population—in California, they range in population from zero to over 100,000 persons. Any indicator that is measured as a rate will be highly sensitive to the population of the Zip Code. In a Zip Code with just a few live births, all it takes is a single LBW to produce a misleadingly high *rate* of LBW infants.

Figure E: Low Birth Weight Indicator for Bay Area and Los Angeles Area



Source: (California Environmental Protection Agency Office of Environmental Health Hazard Assessment 2012b, 31).

Figure F: Percent Low Birth Weight vs. Number of Live Births for California Zip Codes, 2010, Presented on Linear and Logarithmic Horizontal Scales



The dataset OEHHA proposes to use, which was obtained by the California Department of Health, shows that in 2010 the number of live births by Zip Code ranged from five to 2,304.[96] When the percent of births that are LBW is plotted against the number of live births, it is obvious that the distribution of the LBW rate is highly asymmetric, with high LBW rate Zip Codes concentrated among Zip Codes with few live births. When the LBW rate is plotted against the logarithm of the number of live births, patterns in the LBW rate become visible as a series of downward sloping curves of varying steepness. The reason is that, for Zip Codes where there were few live births, the LBW rate is simply an artifact of small samples—i.e., Zip Codes with the number of live births less than about 300. Of the 1,530 Zip Codes for which the California Department of Public Health reported data, about 860 (56%) are below this threshold.

[96] California Department of Public Health (2010a).

In short, the proposed LBW rate indicator contains little or no relevant information and a great deal of information that either has no meaning or is highly misleading. Scientific evidence supporting an association between LBW and pollution is extraordinarily weak. OEHHA has identified only one epidemiological study reporting such a result; its magnitude is too small to be medically important; and no plausible biological mechanism has been proposed explaining why ambient air pollution could be its cause. Alone, this would add noise rather than signal to the model. But using the LBW *rate* as the proposed indicator also injects bias, increasing the scores of relatively high income Zip Codes in which women disproportionately delay childbearing and/or rely on artificial reproductive technology to conceive, both of which increase the risk of LBW. Finally, because the number of live births per Zip Code varies by a factor of more than 1,000, with more than half of all California Zip Codes reporting a small number of live births, the LBW rate is largely an artifact of small sample size.

Asthma ER visits

OEHHA proposes to use as its asthma indicator of public health effects from air pollution, but the Draft Report acknowledges that asthma has many other causes, including "pollen, pet dander, tobacco smoke, mold, and other substances,"[97] none of which have been controlled for. To the extent that this indicator captures asthma caused by factors other than air pollution, it will inject bias into the scoring tool.

OEHHA's proposed asthma indicator—three-year average, age-adjusted rate of asthma emergency department visits (2007-2009)—is likely to result in systematic misclassification. For children, a plausible case might be made that their condition is causally associated with residential location. Nonetheless, even for children the assumption that asthma is caused by pollution is unjustified unless the confounding effects of factors such as "pollen, pet dander, tobacco smoke, mold, and other substances" are controlled for. Failing to control for them implicitly denies that they are important and attributes health effects due to non-environmental causes to some amorphous source of "pollution." This error is analogous to assigning mortality from firearms to pollution on the ground that it is a form of lead poisoning.

For adults, even if asthma were solely caused by environmental factors, assignment to one's current residential Zip Code makes no biological sense. Chronic conditions are the product of chronic exposure, which means that exposure must be weighted by the length of residential tenure across Zip Codes in which the asthmatic has lived. The proposed indicator does not take account of prior residential Zip Codes, so it implicitly assumes that all exposure occurring in other Zip Codes can be attributed to the most current one.

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[97] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 24.

Using emergency department (ED) visits for asthma treatment imparts another systematic bias. Reliance on hospital EDs for non-emergency medical care is correlated with whether the individual is covered by private or public insurance programs such as Medicare, Medi-Cal, and California's Healthy Families Program (S-CHIP).[98] Federal data indicate that privately insured and uninsured patients each comprise about 20% of emergency department visits by 18-64-year olds, but about 40% are Medicaid beneficiaries.[99] Whatever the reasons why Medicaid beneficiaries are twice as likely to rely on hospital EDs, there is no reason to believe that it will be different for asthma than for other conditions.

Heart disease mortality rate

Heart disease is a chronic condition resulting from multiple factors including genetics, diet, and myriad lifestyle choices.[100] Including it as an indicator of public health effects from pollution is problematic because the contribution made by air pollution is at best small, as evidenced by the low relative risk estimates from epidemiologic research. As is the case for other prospective indicators that are weakly correlated with emissions and releases, including heart disease adds much more noise than signal to screening tool, biasing scores toward the mean. Scores in bona fide EJ communities will be attenuated, while scores in non-EJ communities will be exaggerated.

Even if heart disease is assumed to be solely caused by exposure to pollution, the Draft Report errs by incorrectly assigning the full burden to the Zip Code of residence at death. Each Zip Code of residence should properly be assigned a share, perhaps proportionate to the fraction of lifetime spent therein.[101]

Assignment to the last Zip Code of residence imparts other forms of misclassification as well. For example, heart disease mortality is primarily an affliction of age, and people may choose to retire or move into assisted living facilities located in different places than where they were exposed. To the extent that the elderly congregate in such places for reasons of choice or medical convenience, scores for such places would be artificially inflated for non-environmental reasons.

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[98] Nationwide, more than 90% of children under 18 are covered by Medicaid or private insurance. See Centers for Disease Control and Prevention (2011), Figure 14.

[99] Ibid., Figure 17. Medicaid does not require beneficiaries to obtain medical care for asthma in hospital emergency departments. Thus, the high hospital ED utilization rate among Medicaid beneficiaries is primarily cultural, not the result of limited access to health care.

[100] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 28: "Risk factors for the development of heart disease include high cholesterol, high blood pressure, diabetes, cigarette smoking, obesity, and physical inactivity."

[101] Proportional allocation would be consistent with the conventional assumption that chronic health risk is a function of cumulative lifetime exposure.

Apart from these concerns, the Draft Report implicitly makes other assumptions that are highly likely to be false. For example, it assumes that small differences in average mortality across California counties are statistically meaningful. It is apparent from reviewing the underlying data, however, that for many counties mortality from heart disease is not statistically significant from the statewide average.

Figure G plots average heart disease mortality for all but three California counties, along with the reported 5th and 95th percent confidence intervals.[102] Eleven and 15 counties, respectively, have statistically significant lower or higher average mortality rates than the State as a whole. Means for the remaining 30 counties, however, are not statistically significant from the statewide mean.[103] Nonetheless, the Draft Report treats every difference between counties as significantly different from the Statewide mean.

The Draft Report also assumes that each county mean is significantly different from every other county mean. For example, on the map published in the Draft Report (at 29), Alameda County (2008 mean = 143.9 per 100,000) receives a higher score than San Francisco County (2008 mean = 136.1 per 100,000), and San Mateo County gets a lower score. However, the 95th percent confidence interval for San Francisco County (143.4) is above the 5th percent confidence interval for Alameda County (137.7). The 95th percent confidence interval for San Mateo County (137.0) exceeds the 5th percentile for San Francisco County (128.9). According to conventional practices in hypothesis testing, San Francisco County's 2008 average heart disease mortality rate was not significantly different from San Mateo or Alameda Counties.

The Draft Report also assumes that differences in average heart disease mortality rates across counties are meaningful for reasons that are geographically related to EJ impacts. County-level average mortality rates will differ for a host of reasons, including chance. It is not appropriate to simply assume that all variability across counties is biologically meaningful, that geographic variation always can be inferred to have meaning in an EJ context, or that the role of chance can be ignored. Each of these deficiencies exists independently of the primary one noted above—chronic health risk cannot be legitimately assigned to the Zip Code of residence at death.

In short, the proposed indicator for heart disease mortality has no value as an independent variable explaining cumulative impacts from pollution. Heart disease is not predominantly caused by pollution, and to the extent individual cases might be, they would be noise within the confidence intervals of countywide statistics. Including this indicator does not add any useful signal to the model, and it may inject substantial bias. Mortality from heart disease is causally associated with age, and age at death is likely to be correlated

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[102] See California Department of Public Health (2010b). Forty counties are identified as displaying a statistically significant negative temporal trend. No statistical comparisons are provided across counties. Alpine, Mono, and Sierra Counties are excluded because the Department of Public Health cautions that their means are unreliable due to small numbers of observations.

[103] The 5th percent confidence interval for Los Angeles County (171.6 per 100,000) is barely above the 95th percent confidence interval for the State (168.1 per 100,000).

with where the elderly choose to retire. None of these considerations has anything to do with pollution.

Cancer mortality rate

This indicator has the same problems as the proposed indicator for heart disease. It is exacerbated by the Draft Report's cavalier description of the association between cancer mortality rates and pollution, which makes it appear that environmental causes predominate over genetics, lifestyle choices such as smoking, and age.[104]

Figure H plots the 2008 means and confidence intervals for each county, with State and U.S. figures for comparison. Twelve and 18 counties, respectively, have mean 2008 cancer mortality rates that are significantly lower or higher than the statewide average. Means for the remaining twenty-seven counties[105] are not significantly different. But the Draft Report treats every county's mean as fixed, without uncertainty, and thus significantly different from each other and the statewide mean. As in the case of heart disease, the Draft Report also assumes that every county's rate is statistically significant from every other county, and that these differences are geographically meaningful and not due to other factors or chance.

Figure I shows how cancer incidence and mortality differ geographically, using the dame data on which the Draft Report relies, and dividing counties into deciles as OEHHA does. It is clear that the choice of indicator has an effect on scores.

These maps also suggest that differences in county-level cancer incidence and mortality do not correlate with intuitively plausible pollution pathways. Counties with the highest incidence and mortality rates (shown in darker shades of brown) are distant from sources of elevated air pollution (the only exposure metrics in the model for which county-level resolution might make sense). Local pollution sources also appear implausible because population density in the counties with the highest rates is low as well, making it difficult for local sources to exert countywide effects.

In short, the proposed indicator for cancer mortality has no value as an independent variable explaining cumulative impacts from pollution. Cancer is not predominantly caused by pollution, and to the extent individual cases might be, they would be noise within the confidence intervals of countywide statistics. Including this indicator does not add any useful signal to the model, and it may inject substantial bias. Like heart disease, cancer mortality is causally associated with age, and age at death is likely to be correlated with where the elderly choose to retire. None of these considerations has anything to do with pollution.

Environmental Effect Indicators

Like public health impacts that are implausibly associated with exposure to pollution except in isolated cases, the proposed indicators for environmental effects have

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[104] Most surprisingly, OEHHA implies that *occupational* exposure is immaterial.
[105] Alpine County is excluded due to small numbers.

similar deficiencies because they are at best weakly associated with exposure to pollution. For solid and hazardous waste disposal facilities constructed and operated in compliance with federal regulations, no environmental effects caused by exposure to pollution are even plausible because releases resulting in exposure are not permitted. Abandoned waste sites might result in exposure, but any such exposures would be highly localized and thus not shared by even a small fraction of the residents in a Zip Code.

The proposed environmental effects indicators appear to have been selected not because they are relevant to cumulative impacts, but rather because the data exist and are convenient. Ironically, these data are the product of stringent regulations that were intended to prevent exposures that could ever lead to environmental effects. It is not appropriate to say that facilities impose environmental effects even if they are regulated in a manner that prevents exposure.

Cleanup sites

Contaminated waste sites could be environmental effects of pollution, but any such indicator should capture evidence of actual environmental impact. The proposed indicator does not do so. Neither human nor environmental exposure to disposed chemicals is accounted for, which means risk is not a relevant factor. The subjectively constructed index accounts only for the type of site and its regulatory status, both of which are arbitrary characteristics. When more than one waste site is located in a Zip Code, these index values are summed even though there is no evidence suggesting that addition is a valid arithmetic operator to apply.

The index assigns the highest value ("12") to sites that have a "confirmed release" with "generally high-priority" that pose "high potential risk." Meanwhile, the lowest score ("2") is assigned to sites described as in "evaluation" and "certified," "completed," or requiring "no further action." Taken at face value, however, the only sites that should be assigned this score are false positives, sites for which no response was ever warranted.[106] It is hard to fathom why the presumptive EJ impact is only a factor of six between the worst sites in the State and sites for which no action at all was justified. By assigning any positive score to these latter sites, the Draft Report seems to adopt a *Hotel California* approach to characterizing the environmental impact of waste sites.[107]

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[106] See California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 68. To be in the "low" status column, a site must have had (1) a "confirmed release that [was] subsequently certified by DTSC as having been remediated satisfactorily," (2) "completed," or (3) qualify for "no further action." The first two of these are infeasible for sites in the "evaluation" row, which is defined as having "suspected, but unconfirmed" contamination or "have gone through a limited investigation and assessment process."

[107] Once admitted to the regulatory program, a site can check out anytime but it can never leave.

Figure G: Age-Adjusted Heart Disease Mortality (2005-09) by County

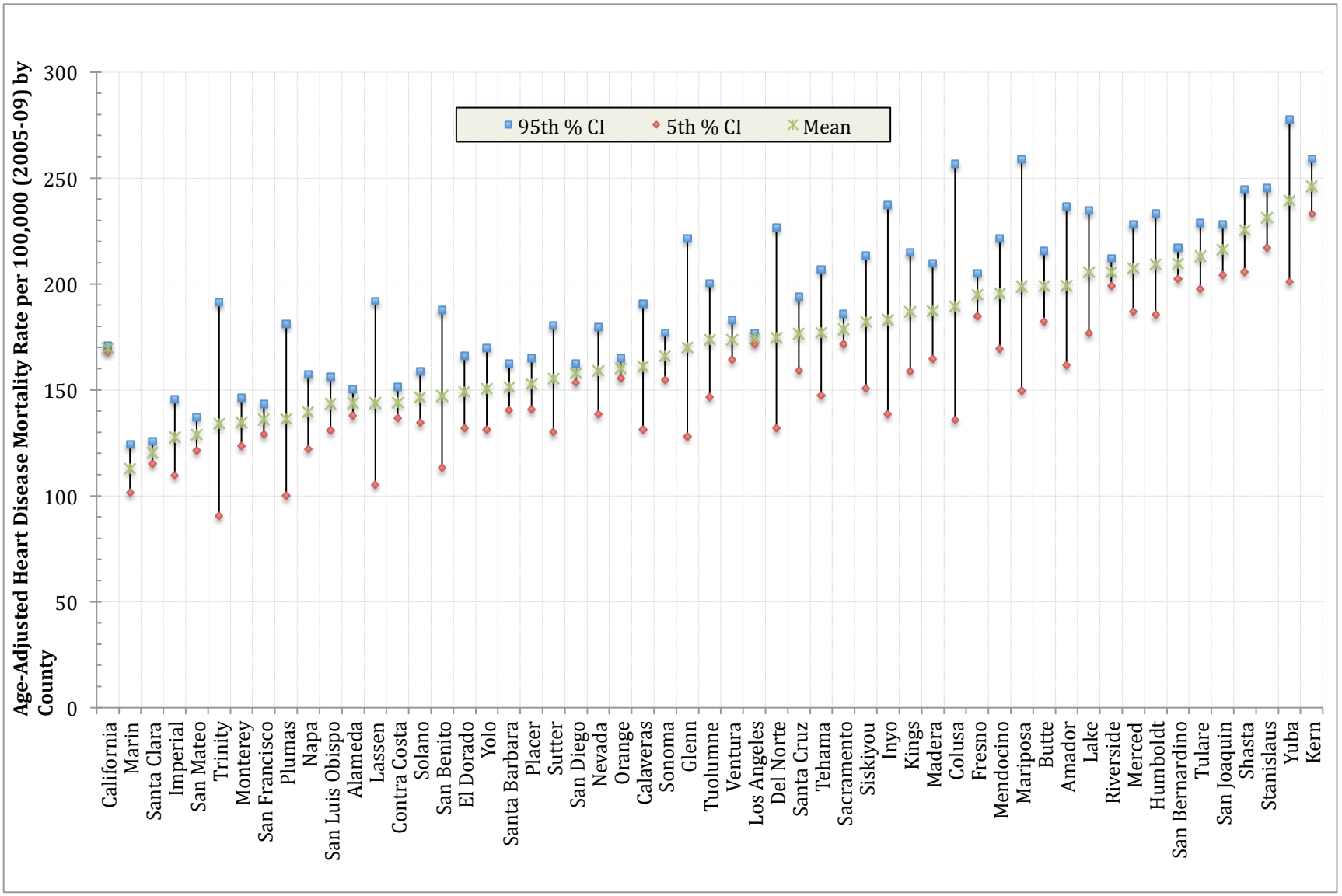


Figure H: Age-Adjusted Cancer Mortality (2005-09) by County

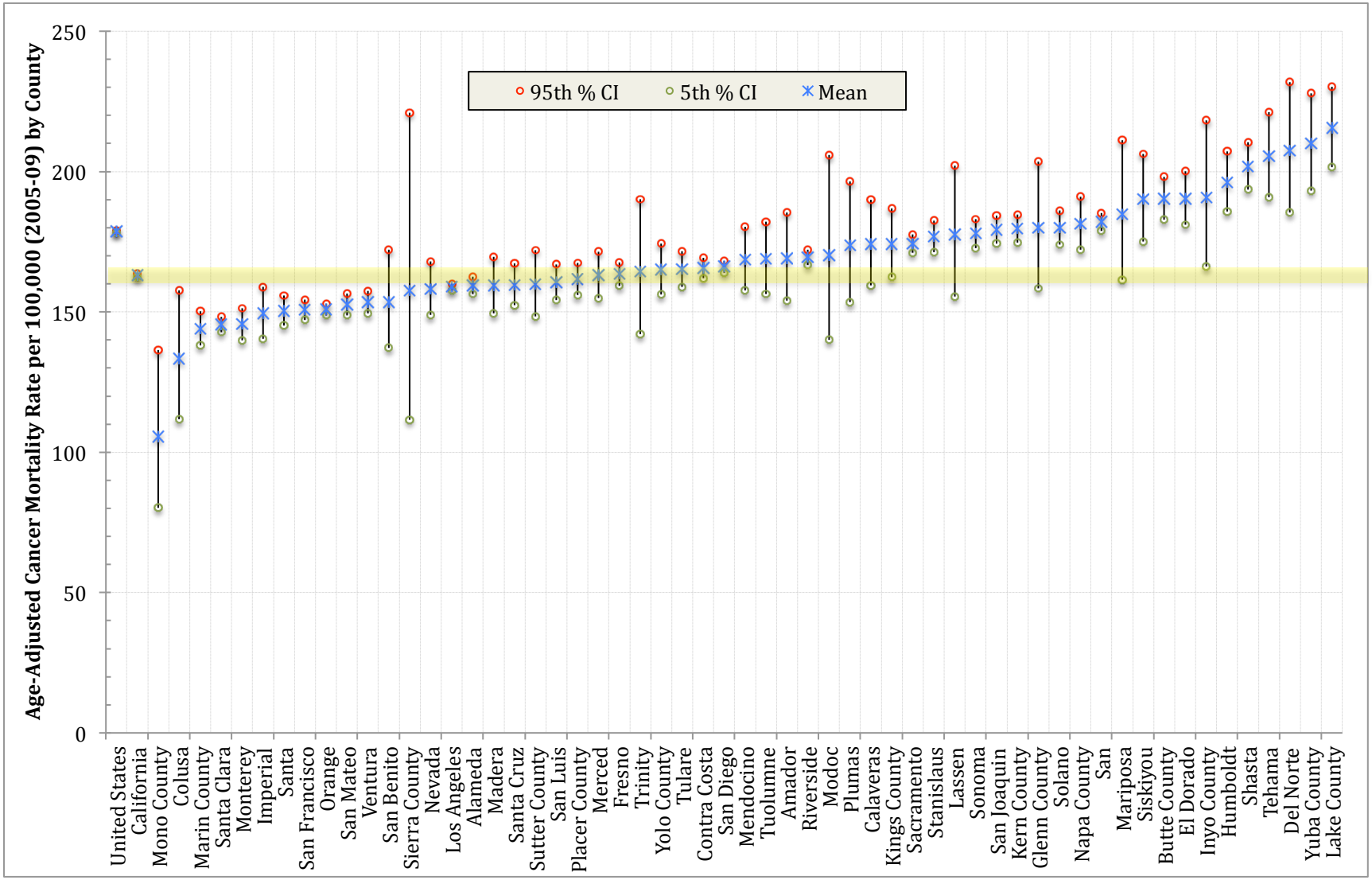
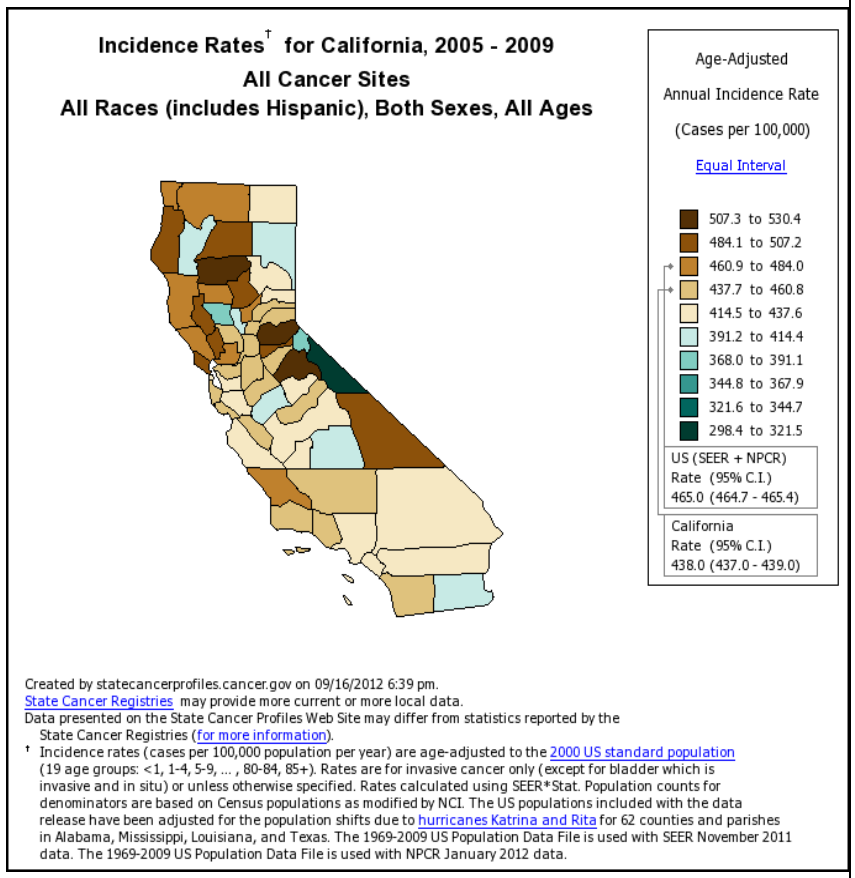
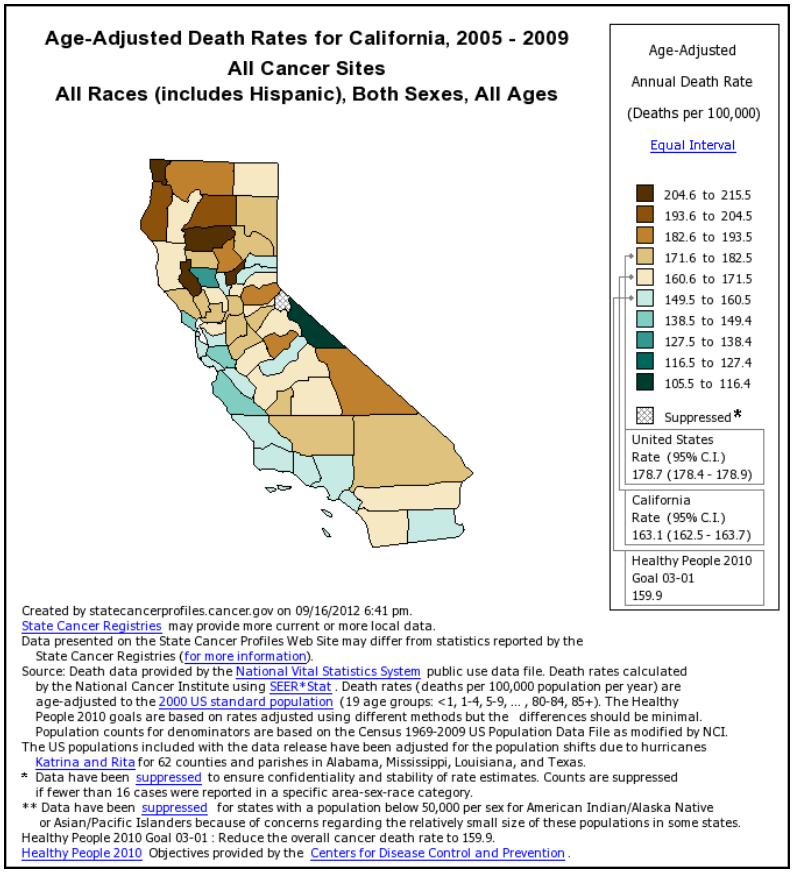


Figure I: Cancer Incidence and Mortality (2005-09) by County





A more scientific approach to estimating the relative impact of waste sites is to estimate the extent to which they reduce the value of neighboring properties. It is well established in economic theory that the value of known environmental amenities and disamenities are captured by market prices, and there is an extensive empirical literature as well. While no publicly available database exists that contains a systematic collection of capitalized values for cleanup sites, a starting point would be to identify the upper bound of environmental effects from such sites, with lesser sites given commensurately less weight. It is virtually certain that the range of property value losses will exceed the six-fold range used in the Draft Report.

It is notable that OEHHA is concerned about the extent to which sites may have become "brownfields" primarily because of liability concerns.[108] Similar views have been expressed in the Cal/EPA Environmental Justice Action Plan[109] and the final report of the Agency's EJ advisory board.[110] These adverse effects may be less the result of environmental contamination than the product of government action that created the financial risk and uncertainty that impedes redevelopment. Of course, to the extent that the EJ scoring tool has a similar redlining effect on communities with high scores, implementing the scoring tool will have its own adverse effects.

In short, this proposed indicator has little or no correlation with actual environmental effects, and thus it only adds noise to the composite score. Sites are permanent geographic features, so perhaps this indicator is best viewed as an indirect device for automatically delivering points to communities that have ever hosted a waste site.

Leaking underground storage tanks

The Draft Report is not clear about what this subjectively defined and scored indicator is intended to measure. The text alludes to concern about drinking water supplies that might be "affected or threatened," but the proposed indicator is not limited to those circumstances. It also mentions a concern about the "potential for exposure to hazardous substances through the inhalation of vapors," but this would equate environmental effects *from* exposure with merely *potential* exposure, which the CI definition does not appear to permit and would, in any case, dilute the indicator's utility. Finally, the text suggests that

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[108] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 34; and California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2010), 1, 27.

[109] California Environmental Protection Agency (2004), 53.

[110] California Environmental Protection Agency Advisory Committee on Environmental Justice (2003), 28. The advisory board sought to convert brownfields into affordable housing. The advisory committee recommended that the State "[p]rovide fiscal and regulatory incentives to communities, local governments, and developers" as long as they did not lead to less protective cleanup standards. Thus, there is widespread agreement with the principle that a final EJ scoring tool must be used to relieve burdens on EJ communities, not increase them.

land adjacent to leaking underground storage tanks "may be taken out of service and compromised due to perceived cleanup costs or concerns about liability," but the indicator is insensitive to whether any such action has been taken.[111]

No justification is given for the use of a 3-15 point scoring range, which is both different from and greater than the 2-12 point range used for hazardous waste sites. Like the proposed cleanup site indicator, values assigned to each datum are arbitrary and sites that pose no measureable environmental hazard do not receive a zero score. More weight is given to a site's status in the regulatory enforcement pipeline than any objective measure of environmental impact that would be observable to community residents.

Solid and hazardous waste sites and facilities

This indictor is like the preceding indicators, and has the same problems and limitations, but it applies to different facility types. The justification given in the Draft Report is similarly ill defined. The text acknowledges that there is a fundamental difference in actual (and even hypothetical) environmental impacts between older facilities and those built and operated in compliance with the latest standards because the latter "are designed to *prevent* the contamination of air, water, and soil with hazardous materials" (emphasis added). Composting and recycling facilities may pose environmental effects due to concerns about "odors, vermin, and increased truck traffic."[112]

The proposed indicator makes no distinctions on these margins and gives no weight to the effectiveness of federal and State regulation. The Draft Report proposes to deem them all detriments to their host communities. This is certainly ironic inasmuch as they were established expressly to provide an environmental *benefit*, and undoubtedly they were promoted at the time as environmentally benign.

The subjective method for constructing indicator scores in the Draft Report is not amenable to independent review and validation because too little information is disclosed. It appears, however, that like other indicators in the environmental effects suite, this one gives weight primarily to a site's regulatory status, not any objective measure of environmental effects. Differences in subjective scores across site types and regulatory violations appear to be arbitrary, not risk-based. Indeed, to the extent that risk matters, hypothetical risk gets most of the attention, not actual risk. The proposed model has a built-in bias against both commercial and off-site hazardous waste facilities, for reasons the Draft Report does not explain.

Like the others preceding it, this proposed indicator has little or no correlation with actual environmental effects, and thus it only adds noise to the composite score. Like cleanup sites, waste disposal facilities are permanent geographic features, reinforcing the notion that this indicator is an indirect device for automatically delivering points to communities that host them.

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[111] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 38.

[112] Ibid., 40.

Impaired water bodies

It is certainly plausible that impaired water bodies have adverse environmental effects, but whether these effects are real depends on how impaired water bodies are defined. The Draft Report proposes to rely on the definition implied by Section 303(d) of the Clean Water Act, as interpreted and implemented by the State Water Resources Control Board (SWRQB), and complied in the SWRQB's (presumably 2010) Integrated Report.[113]

A review of the maps identifying all Section 303(d)-listed waters in selected areas shows that this definition is too broad and poorly targeted for use as an indictor of EJ-related environmental effects. For example, Figure J shows the waters of Los Angeles County that are listed as "impaired." This list includes, among others, the Los Angeles River. Residing near such a "river" may be an environmental disamenity, though if so it is likely because these "rivers" are concrete-lined channels used almost exclusively for flood control. If adjacent communities consider them environmental disamenities, the absence of pollutants in excess of federal and State regulatory standards seems unlikely to have any effect.

On the other hand, the entire coastline of Los Angeles County is designated as "impaired," which should come as a surprise to almost everyone familiar with it. Communities hugging the beach have the most coveted real estate in the County. It is inconceivable that they experience bona fide EJ-related environmental effects. By giving spurious weight to the wealthiest and most favorably endowed communities anywhere in the State, it is clear that this proposed indicator is poorly designed for its intended purpose.[114]

Sensitive Population Indicators

The decision to give special attention to sensitive subpopulations is by definition strictly policy-driven, though it appears to have been substantially influenced by scientific studies reporting that the very young and the very old may be more susceptible to environmental insults. Even if this scientific evidence is assumed to be correct, it is not clear that the Draft Report properly accounts for it. The Draft Report appears to oversimplify the science, attributing sensitivity to a much broader group of people than the science supports. By doing so it gives extraordinary weight to geographic clusters of older adults without regard for why they are co-located, and it confers a benefit on people who in general are unlikely to have legitimate EJ concerns.

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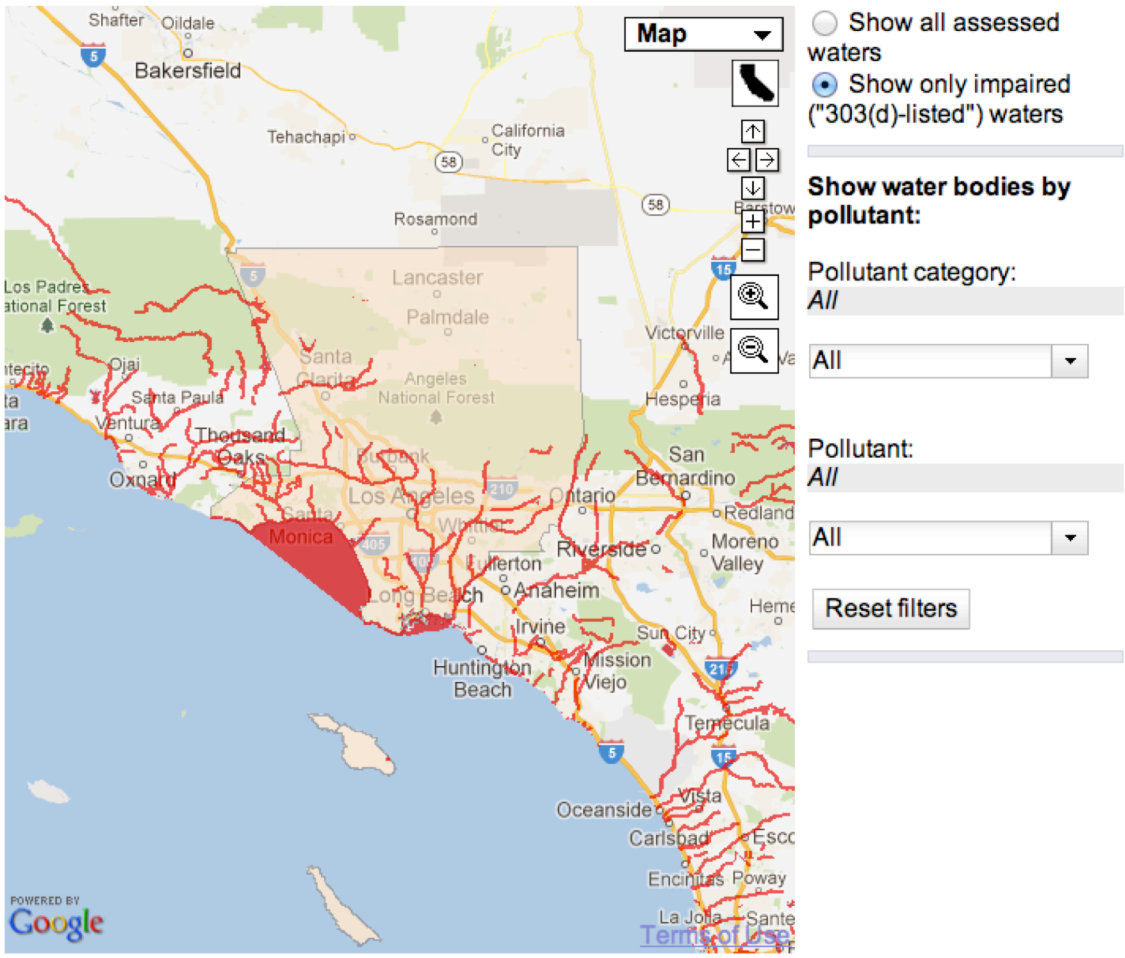
[113] California Environmental Protection Agency State Water Resources Control Board (2011).

[114] A review of the "impaired water bodies" of Marin County yields a similar reaction. All of San Francisco Bay is deemed impaired, which implies that the Town of Tiburon and the City of Sausalito both suffer adverse environmental effects from pollution. Tomales Bay is similarly disadvantaged.

Figure J: "Impaired Water Bodies" (2010), Los Angeles County



The Draft Report oversimplifies biological sensitivity.

The Draft Report appears to be caught in a dilemma created by the CI Report, which concluded that the very young and the very old were more sensitive to pollution than the population at large.[115] The dilemma arises because sensitivity among these age groups is not generalized, but focused on subpopulations within them whose health is impaired for other specific reasons. Being elderly is not per se evidence of sensitivity, but being elderly

[115] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2010).

and infirm probably is, and the likelihood of being infirm is greater for the elderly than others.

The CI Report oversimplified the science and incorrectly imputed the causal relationship between this two-dimensional condition (elderly *and* infirm) to age alone. This invited the creation of overly broad indicators of sensitivity. That problem, in turn, was exacerbated by the highly negative correlation at the Zip Code level between the fractions of children under five and adults over 65.[116] It was for this reason that OEHHA devised a composite indicator for age sensitivity to capture Zip Codes with disproportionate numbers of either age group. Separate indicators would have largely canceled each other out.

This oversimplification is apparent, though it went unrecognized, in the OEHHA staff application of the proposed screening tool to 30 Zip Codes. The authors were quick to note that these Zip Codes exhibited a high correlation between mortality from cancer or heart disease, but they neglected to notice that both indicators were even more strongly correlated with age.[117] When examined by themselves, correlation coefficients for age 65+ suggested no connection to actual or even hypothetical pollution exposure ($\rho = -0.33$ for PM2.5; $\rho = -0.31$ for ozone; $\rho = -0.45$ for TRI releases; $\rho = -0.50$ for pesticides).

In short, the inference that Zip Codes with a lot of children under five <u>or</u> adults over 65 are collectively more sensitive to pollution is difficult to support scientifically. It would help if, for example, OEHHA could muster evidence that various illnesses logically attributable to geography (which is essential for pollution exposure to be relevant) are significantly more prevalent in these Zip Codes than others. If no such illnesses can be identified, or they are distributed in proportion to the numbers of children under five or adults over 65, then geographic co-location is mere coincidence, with no plausible EJ interpretation.

Older adults cluster residentially for reasons unrelated to EJ.

Any tool that gives special weight to geographical clusters of retired adults must contend with a serious misclassification problem. Over time, communities can develop concentrations of older adults for a number of economic reasons. For example, older suburban communities may have become incompatible with children because homes are too small by contemporary standards, or housing prices are too expensive for young families. Older adults may find themselves surrounded by other older adults even if they never move.

Of course, many older adults do move, especially after retirement. Popular retirement destinations typically have communities that cater to older adults. These communities will tend to have lower housing costs, greater investment in amenities that

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[116] The correlation between the population percentage under five years and over 65 years in the OEHHA staff sample of 30 Zip Codes was -0.80. <u>See</u> August, Faust, Cushing, Zeise and Alexeeff (2012), 3080. It is also not clear why OEHHA decided to focus on adults over 65, as opposed to say, 75 or 80—ages that are unambiguously elderly.

[117] Ibid.,

older adults prefer, and less investment in amenities and infrastructure that attract young families. In short, older adults may choose to live in communities comprised of other older adults. In these communities, it is difficult to identify EJ-related concerns even if they have social characteristics that superficially suggest otherwise.[118]

In any case, an EJ screening tool that gives extra weight to communities in which older adults choose to cluster is inconsistent with policymakers' intent. These communities appear highly unlikely to exhibit a measurably unusual sensitivity to pollution.

Giving extra weight to communities with disproportionate numbers of older adults undermines the legitimacy of the tool for EJ screening

Giving special weight to adults over 65 also may be inconsistent with policymakers' intent because wealth in the United States, not poverty, is concentrated among members of this age group. The Pew Research Center has reported that households headed by someone 65-years of age or older had median net worth 47 times as great as households headed by adults younger than 35 years of age. Moreover, between 1984 and 2009, these older households experienced on average a 42% increase in net worth, while households headed by adults under 35 saw a 68% decline. Thus, gaps in net worth favoring older households that were present in 1984 have only increased. Paired snapshots for the two years for each age group are shown in Figure K below.[119]

The concentration of increases in net worth parallels changes in median household income. From 1967 to 2010, average real adjusted household income across all households rose by 45%. However, among households headed by a person 65 years old or more, median real adjusted household income rose by 109%. Further contradicting the conventional wisdom that older households are disproportionately poor, the share of households headed by a person 65 years of age and older in poverty has declined from 35% in 1967 to 11% in 2010. Meanwhile, the percentage of households headed by a person under 35 years old in poverty has nearly doubled, increasing from 12% to 22%.[120]

If OEHHA continues to believe that it must "take account" of the special sensitivities of some older adults, it would make sense to identify a much more selective indicator than the proportion of *all* older adults in a geographic unit.

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[118] For example, it has been reported that some communities with higher than average rates of sexually transmitted disease are retirement communities. See, e.g., Jameson (2011). This underscores, among other things, the arbitrary nature of using 65 years as the lower bound for "elderly." In 2007, the average life expectancy of 65-year olds had increased to 18.6 years, and 15.2 years for black males—the cohort whose average longevity at birth has for decades been the lowest. See Arias (2011), 2 [Table A].

[119] Fry, et al. (2011). To the extent that accumulated home equity was a major contributor to increases in net worth by those over 65, the 2007-09 recession and continuing lagging real estate market probably reduced this gap.

[120] Ibid., see tables. *Real* income means adjusted for inflation. *Adjusted* income means controlling for household size (see Appendix A). *Net worth* is assets minus debt.

Socioeconomic Factor Indicators

The various indicators proposed for this suite appear to be intended to do double duty, as measures of sensitive populations and "non-intrinsic factors [that] may also modify the response to pollutant-mediated adverse effects."[121] The justifications for inclusion are consistently amorphous, permitting a sort of free-range association that allows a wide range of interpretations and clearly excludes few. The scoring tool would be improved if OEHHA made clearer distinctions between those indicators proposed for inclusion because of biological sensitivity (in principle a scientific determination) and indicators proposed for inclusion to intentionally bias composite scores in favor of communities deemed to be disadvantaged for one reason or another.

An alternative view is that certain socioeconomic factors are not merely associated with adverse health outcomes, whether from pollution or other causes, but they are themselves the primary underlying causes of environmental inequality. As was noted in the first section on economics, environmental quality is a normal good, and possibly a luxury good. Demand rises with income, and if it is in fact a luxury good, demand rises at a rate faster than income across some range of incomes. Under this model, differences in environmental amenities and disamenities are not coincident with differences in income or wealth; they are a predictable result of such differences.

With this in mind, in this section each of the proposed socioeconomic indicators is examined for whether it clearly distinguishes communities that policymakers intend to make better off by conducting EJ scoring and utilizing the results.

Percent of adult population with less than a high school education

The Draft Report justifies the inclusion of this indicator on the ground that "disadvantaged populations have increased vulnerability to the health impacts of pollution" and educational attainment is "[a]n important social determinant of health. Supporting examples consist of raw associations between various health outcomes and educational attainment without regard for the effectiveness of statistical control for confounders. No mechanism is stated suggesting what the *proportion* of residents with low education might measure about a community, or why it is germane to EJ.[122]

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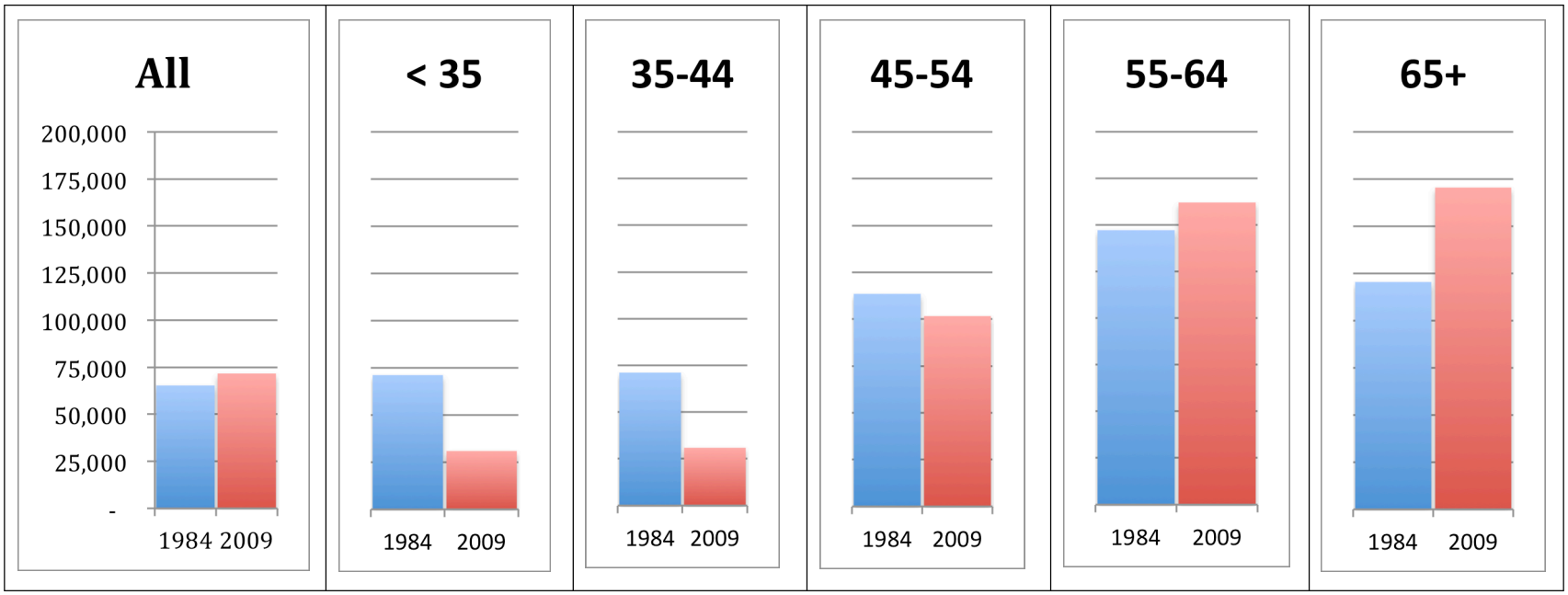
[121] Alexeeff, Faust, August, Milanes, Randles, Zeise and Denton (2012), 650. What is means exactly for these indicators to "modify the response" is not clearly articulated, thus exacerbating readers' confusion about how socioeconomic factors differ from sensitivity.

[122] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 50. This indicator is one for which OEHHA has discarded information at the Census tract level in order to accommodate its Zip Code-based default geographic unit.

Figure K: Increase in Net Worth 1984-2008 by Age Group



Source: Fry et al. (2011).

As has been noted above, indicators expressed as percentages are unusually susceptible to artifactual volatility resulting from a large number of California Zip Codes containing small numbers of people. In December 2010, the average number of residents in a California Zip Code was 21,068; the median was more than 25% lower (15,499), illustrating the distribution's asymmetry. Sixty-four Zip Codes contain 100 persons or less, and 352 Zip Codes contain under 1,000. In the case of the proposed low birth weight (LBW) indicator, it was shown that communities that ranked high for LBW rate were highly likely to have had few live births. Rankings in the upper tail of the proposed indicator—the range of the distribution of greatest potential relevance—were artifacts of Zip Codes with small populations. A similar problem seems likely for this proposed indicator, which also is a rate susceptible to volatility resulting from small samples.

OEHHA's focus on adults may create additional problems. Barring substantial residential mobility, the distribution of years of schooling among adults is unlikely to change over time. Thus, community rankings are likely to be essentially fixed over time because their scores will be insensitive to both public policy and market forces.

An alternative approach might be to focus instead on children, whose educational attainments are incomplete and susceptible to improvement. State and local officials have levers to influence future school quality, and this is everywhere a high priority. OEHHA could, for example, develop and implement an indicator of elementary school quality and assign each school's quality score to the community it serves.123 School quality scores could provide a highly targeted indicator of neighborhood attributes that coarse indicators such as the one proposed cannot. Also, they would not be susceptible to the problems associated with small sample sizes that rate-based indicators cannot easily avoid.

Median household income

The Draft Report justifies the inclusion of an income indicator for the same reasons as adult educational attainment, thus it suffers from the same reader confusion concerning its purpose.[124] From an economics perspective, income is the *sine qua non* of differences in the distribution of environmental amenities and disamenities. This does not mean that low income is per se evidence of environmental inequity. Because environmental quality is a normal (and perhaps luxury) good, low-income households on average prefer less of it than high-income households, and more of other things. They are made worse off if they are required to have as much environmental quality as their wealthier neighbors. If they were given extra units of environmental quality but were permitted to exchange it for other goods and services, by and large that is exactly what they would do.

The specific household income indicator proposed for use is a reasonable one, though it is not clear if these are real or nominal values or exactly how it was

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[123] The California Department of Education has developed multiple quality indicators that OEHHA could consider, including the Academic Performance Index. See California Department of Education (2012).

[124] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 52. The relevant text for both indicators is identical.

constructed.[125] Like some other proposed indicators, OEHHA discarded useful data to develop Zip Code level estimates. High quality data should never be discarded.

Because the focus of EJ screening is on the tails of various distributions—in this case, the lower tail—it is not obvious that a central tendency indicator of household income is best. It may be more important to attempt to identify a sensitive and selective indicator of the lower tail, such as perhaps the household income corresponding to a fixed percentile (e.g., 10th) or a fixed real dollar amount.

Whether the indicator represents a central tendency or an arbitrary but meaningful percentile of the distribution, it should be adjusted for differences in purchasing power. The same amount of income means very different standards of living in Russian Hill and Whiskeytown. The absence of control for purchasing power gives rural communities higher scores than is justified.

Percent of population living below two times the national level defining "poverty"

The idea is well established that the "poverty rate" is a useful comprehensive indicator of economic disadvantage. In fact, there are multiple indicators available. The Census Bureau and the U.S. Department of Health and Human Services (DHHS) have different definitions for the indicators they use. Whereas Census defines "poverty thresholds,"[126] DHHS has "poverty guidelines" that differ by household size and are calculated separately for Alaska and Hawaii, and are used for defining eligibility for various federal programs,[127] and there are a number of experimental measures. [128] It is the Census Bureau's "poverty threshold" that is most often cited, however, and it is the one on which the proposed EJ indicator is based.[129]

All poverty measures are problematic for use in EJ screening, however, because they do not account for even state-level differences, except as noted above for DHHS' adjustments for Alaska and Hawaii with respect to the version used to establish federal programmatic eligibility. There is no reason to believe that a national rate is appropriate for California. Thus, for every Zip Code the denominator in the calculation of the indicator

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[125] The Draft Report says (at 52) that "[a]verages of the median household income were calculated for each census tract." Real values are superior to nominal values because they control for inflation. Also, it makes more sense to take an average of means than an average of medians. If the underlying distributions are not normal, they can be transformed before inclusion in the scoring tool.

[126] U.S. Census Bureau (2012c).

[127] U.S. Department of Health and Human Services Office of the Assistant Secretary for Planning and Evaluation (2012).

[128] U.S. Census Bureau (2012d).

[129] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 54. In fact, the proposed indicator is one of the Census Bureau's definitions of "working poor," which it acknowledges "may mean different things to different data users, based on the question they are trying to answer."

is arbitrary. And, as noted above in the discussion of the median household income indicator, it is essential that dollar-denominated amounts be adjusted for relative purchasing power in different communities in the State.

Finally, this proposed indicator is susceptible to the defects common to other rate-based indicators used in combination with Zip Code level aggregation. Indicator values for Zip Codes with relatively few residents will be volatile and yield values that are unreliable.

Given the high correlation between the income and poverty indicators,[130] combined with the statistical deficiencies associated with rate-based indicators, it would be better of OEHHA dropped the poverty indicator and focused its energy on making adjustments for relative purchasing power.

Race/Ethnicity

The proposed inclusion of specific indicators for race and ethnicity is deeply troubling from a scientific, economic, and ethical perspective. Several arguments are advanced to support in in the Draft Report,[131] but none are persuasive because race is often used in research as a proxy for other phenomena and the control for confounders is likely to be inadequate. Were that not so, OEHHA would be implying that there are either immutable, genetic differences in the distribution of environmental amenities and disamenities in California, or overt racism. Evidence supporting either proposition is not supplied.

There is no doubt that race and ethnicity often provide useful proxies for other phenomena that may be harder to measure. Still, it is important not to lose sight of the fact that when race and ethnicity are used in research of this type, it is always used in lieu of better, more accurate, and more relevant variables that are known to exist but which cannot be measured.

To establish race and ethnicity as an EJ indicator is tantamount to giving up on the proper identification of the true independent variables. Doing so in the context of EJ screening would convert a known and inferior proxy into a hard-wired control variable delivering an entitlement.

From the perspective of State policymakers, nothing could be done to ameliorate the proportion of the composite score that is predicted by race and ethnicity short of forcing intrastate migration. At least as disturbingly, it would reward the perpetuation of de facto residential segregation, for without segregation a community's score, and access to program benefits, would decline. Policies that seek to encourage racial and ethnic integration would become detrimental to access to the benefits of EJ designation.

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[130] See August, Faust, Cushing, Zeise and Alexeeff (2012), 3080, reporting a correlation between the income and poverty indicators in their 30 Zip Code sample of 0.94.

[131] California Environmental Protection Agency Office of Environmental Health Hazard Assessment (2012b), 56.

Alternative Indicators of Population "Vulnerability"

Indicators in the Socioeconomic Factors suite appear to be intended as proxies for factors other than biological sensitivity for which OEHHA wants to give greater weight. This is problematic because the text of the Draft Report and supporting documents use the term "vulnerability" with maximum ambiguity and zero clarity.[132] A credible EJ screening model that incorporates a suite of indicators for vulnerability must include a clear definition of what it means.

If what OEHHA means by community "vulnerability" is its limited ability to withstand a hostile environment, then the Office should be more rigorous about identifying what factors make a community's environment "hostile" and what indicators plausibly measure these factors. Obviously, it also would help if there was a genuine scientific linkage between these factors and the proposed measurement indicators, not just boilerplate text that states a conclusion based on premises not even shown to be relevant.

Of the factors that plausibly limit a community's ability to withstand a hostile environment, it is not clear that community residents would give great weight to purported public health and environmental effects from pollution. This is especially so if the purported public health and environmental effects are quantitatively minor, subtle, or scientifically speculative. Community residents well give much greater weight to factors that are quantitatively major, transparent, or scientifically proven. For example, residents might have trouble understanding how the regulatory status of a solid waste disposal facility increases community vulnerability but have no trouble appreciating how crime, gang activity, and underperforming schools could have that effect.

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[132] "Vulnerability" is mentioned several places in the Draft Report (see, e.g., 1, 5, 7, 50, 52, 54), but the term is not defined. The CI Report mentions "vulnerability" seven times in the body of the report but also does not define it. Of the seven references, one distinguishes it from sensitivity (33), another conflates it with sensitivity (22). For undefined uses of the term "vulnerability," see the Draft Report at 1 (describing the EJ screening tool as "a proposed method for evaluating the cumulative impacts of multiple pollution sources in a community, while accounting for a community's vulnerability to pollution's adverse effects" in which "other community characteristics that have been shown to affect vulnerability to pollution, such as socioeconomic factors"), 5 (establishing as a criterion for indicator selection "indicators [that] represent demographic factors known to influence vulnerability to disease"), 7 ("Socioeconomic factors are community characteristics that result in increased vulnerability to pollutants"). The same textual preface ("Studies have shown that disadvantaged populations have increased vulnerability to the health impacts of pollution") is given to support the inclusion of indicators for adult *educational attainment* (50), median household *income* (52), and *poverty rates* (54). The CI Report states that "a growing body of literature provides evidence of the heightened vulnerability of people of color and lower SES to environmental pollutants" (23), but cites only a single epidemiological study (Bell, et al. (2007)) that was not designed to test such hypotheses, included limited controls for confounders, and provided no biological explanation for its observations.

In Part 1, it was noted that a community's unemployment rate could be a theoretically sound, practically useful, routinely measured, and highly visible indicator of community vulnerability, including community vulnerability to the unintended effects of State efforts to reduce environmental inequality. Data are available at the community but not Zip Code or Census tract level.[133] While finer detail might be welcome, it is important to keep in mind that none of the valid exposure indicators in the proposed model have Zip Code or Census tract-level resolution.

A community unemployment rate indicator would be a useful complement to an income indicator that, as previously recommended, is normalized for regional purchasing power. OEHHA staff already believe that the proposed socioeconomic indicators are highly correlated,[134] and as noted above, each of these proposed indicators has important technical limitations that prevent accurate discernment of the tails of each distribution, an essential requirement for an EJ screening tool. Indeed, it is not clear that any of the other proposed indicators—adult educational achievement, poverty rates, and race/ethnicity—have any genuine value added.

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[133] Figure A displayed monthly unemployment rates for 127 separate communities in Los Angeles County, and similar detail is available for hundreds more California communities.

[134] August, Faust, Cushing, Zeise and Alexeeff (2012), 3080 (educational attainment and income: $\rho = 0.72$; educational attainment and poverty: $\rho = 0.89$; income and poverty: $\rho = 0.94$).

PART 4: NEXT STEPS

The proposed model represents a useful first crack at a difficult task, but as this paper has made clear, it has serious deficiencies that need to be remedied before a second draft is published for public review and comment. These deficiencies extend throughout the model, the selection of indicators, the use of a relative instead of absolute scale for scoring, and numerous other margins. Because of these deficiencies, it is premature to devote much attention to sensitivity analysis, the usual purposes of which cannot be served at this time.[135]

These purposes consist of evaluating the extent to which uncertainties in the outputs of a model can be allocated to various factors. That cannot be done because the Draft Report does not disclose any of the manifold uncertainties known to be present. Similarly, the recent OEHHA staff analysis applying to 30 selected Zip Codes does not provide a credible uncertainty analysis because, like the Draft Report, it does not disclose these uncertainties.[136] Contrary to the authors' conclusions, model validation is not demonstrated just because there is limited variability in outputs across alternative models. They would obtain the same result if all of the models they examined were wrong but happened to share the same flaws.

A useful next step would be to examine the model from top to bottom with a comprehensive look at uncertainty. For example, OEHHA could consider the extent to which its proposed screening tool has each of the types of uncertainty that have been identified by Morgan et al. (1990), and to the extent they do, analyze their consequences.

Before proceeding further, OEHHA should validate the indicators is proposes to use and replace those that cannot be validated. A valid indicator is one that is both sensitive and selective with respect to the phenomenon it seeks to measure or estimate. The indicators proposed thus far certainly are sensitive, but almost all of them have extremely low selectivity. Simply adding more indicators that also have low selectivity will not make their average or sum more selective. When a low-selectivity index of "pollution burden" is multiplied by low-selectivity indices of population sensitivity and socioeconomic vulnerability, the resulting product will be highly non-selective.

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[135] It must be noted once again that too little information has been disclosed. Members of the public cannot come close to reproducing OEHHA's work, much less conduct a sensitivity analysis. Any sensitivity analysis performed by OEHHA would have at least the same disclosure requirements.

[136] August, Faust, Cushing, Zeise and Alexeeff (2012) misuse sensitivity analysis in an effort to confirm model validity. The authors examines only the extent to which rankings would change if changes were made to a few aspects of model structure. These structural changes are smaller at the margin than uncertainties in the data, which remain undisclosed and unaccounted for.

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