Exploring Alternative Environmental Assessment:

A Case Study of the Alameda Corridor of Central Los Angeles

By Oliver Baker, Carina Cuellar, and David Sumi

USC Sustainable Cities Program, Undergraduate Fellows

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Project Advised and Edited By Robert O. Vos, Ph.D., Research Associate, USC Sustainable Cities Program

Project Advisors: USC Professors Mansour Rahimi and Andrea Hricko. Sustainable Cities Program Doctoral Fellows Merrill Weidner and Ana Rosenbluth.

Introduction

Environmental impact assessment is currently performed pursuant to procedures outlined in regulations and case law at the federal and state levels. However, the law and policy behind environmental impact assessments does not inherently limit the range of scientific innovations in performing assessments. Indeed, in some cases, the law may even be seeing as a spur to scientific innovation (Fischman and Squillace, 2000). Two relatively new tools for gauging environmental impacts are life-cycle assessment (LCA) and environmental justice (EJA) analysis (Liu, 2001 and Graedel, 1998). This exploratory research addresses the question: "How might life cycle assessment and environmental justice analysis be incorporated to gauge the environmental impacts of major urban infrastructure projects?"

The study addresses this question through the preliminary application of these methods to a major infrastructure project in Central Los Angeles County, the Alameda Corridor. The Alameda Corridor Project (ACP) functions as a case study of environmental justice analysis and cumulative impact assessment. In order to limit the scope of the research, the case study focuses on the single aspect of air pollution from diesel locomotives and trucks and its relative exposure on different populations. In addition, the study initiates the first stage of LCA, creating a conceptual template for applying life-cycle assessment to the ACP. Finally, the last stage of LCA is anticipated through an analysis of alternative designs for the ACP, especially alternative fuel technologies.

The Current Law and Policy of Environmental Assessment

Under current law and regulation, environmental impact assessments must be conducted for large construction projects like the Alameda Corridor. The National Environmental Policy Act (NEPA) and corresponding state law, the California Environmental Quality Act (CEQA), require a detailed statement by the responsible agencies on

i. the environmental impact of the proposed action,
ii. any adverse environmental effects which cannot be avoided,
iii. alternatives to the proposed action,
iv. the relationship between local short-term uses of man's environment and maintenance and enhancement of long-term productivity, and
v. any irreversible and irretrievable commitments of resources (NEPA Sec. 102 [42 U.S. Code § 4332]).

In addition to this basic framework, President Clinton's 1994 Executive Order 12898 directs all federal agencies to incorporate "environmental justice" as part of their missions in order to protect minorities and low-income populations from disproportionate impact. A memorandum accompanying the Executive Order specifically directs agencies to analyze effects on minority and low-income populations in fulfilling NEPA requirements.

NEPA applies to all federally funded projects, while CEQA pertains to all projects in the state of California. Section 102(2)(C) of the NEPA requires that federal agencies prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. Regulations amended in 1986 by the Council on Environmental Quality (CEQ) further provide for the preparation of Environmental Assessments to provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or to prepare a Finding of No Significant Impact (FONSI). NEPA is merely a procedural statute, in that even though it requires agencies to conduct studies and find alternatives, it does not force agencies to act on this information.

In contrast, CEQA has more of substantive bite, in that officials must apply friendly alternatives or mitigation measures whenever feasible. CEQA requires at least an initial review of the environmental effects of all projects. CEQA considers a project as an activity assumed by either the public or private sector, which requires some discretionary approval from a government, which may cause either a direct physical change in the environment or a reasonably foreseeable indirect change in the environment. Depending on the potential effects, a further, more complete analysis may be required in the form on an environmental impact report (EIR). A program may not be approved as submitted if feasible alternatives or mitigation are able to substantially lessen the potential effects of the project (California Resources Agency, 1998).

Unfortunately, these laws and reports can lead to a false sense of accomplishment. NEPA and CEQA have a number of key shortcomings. Challenges under NEPA target only single sites and do not consider cumulative impacts of multiple sources in close proximity to each other. The statutory language also does not encompass racial diversity. Even though environmental impact assessments under both laws provide for public access and comment, the data is often so technical and unfriendly that most affected residents are unable comprehend the underlying meaning of the reports (Mahoney, 1999). Environmental impact statements and reports as yet often still fail to provide a comprehensive picture of overall environmental impacts to the public.

Another major weakness of both NEPA and CEQA is that they are self-executing statutes that lack ready means of enforcement. Public agencies are entrusted with compliance, but provisions in the law must be enforced by the public through litigation or the threat thereof. While the California Resources Agency may assist public agencies in the interpretation of CEQA, it lets each public agency decide what does and does not apply under CEQA. There is no central authority that reviews state and local agencies for compliance with CEQA.

A Geography of Impacts

Environmental impacts occur on varying spatial and temporal levels (Graedel, 1998). Upon closer examination of spatial impacts, one observes three basic levels of analysis: global, regional, and neighborhood. The first level of analysis is the global level of analysis, which encompasses such widespread problems as global warming due to emissions of greenhouse gases. Analysis at the regional level is concerned with issues that can affect areas that extend beyond the boundaries of traditional municipalities. Finally, the neighborhood level involves very local impacts, such as particulate matter from diesel exhaust.

Unfortunately, global impacts are often overlooked in existing environmental impact statements. Methodologies used in these statements are unable to account for global emissions throughout the life-cycle of a project and global emissions in the construction phase are often ignored. This was the case in environmental documents that were prepared for state and federal decision-makers in the Alameda Corridor Project (U.S. Department of Transportation, 1996). One important advantage to using life-cycle assessment tools is to capture global level emissions.

The lack of accounting for global emissions in traditional impact assessment is not due to an omission in the law. Quite to the contrary, the language of NEPA reveals its clear intention to protect the global environment:

> The Congress authorizes and directs that, to the fullest extent possible…all agencies of the Federal Government shall….recognize the worldwide and long-range character of environmental problems…to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment (NEPA Sec. 102 [42 U.S. Code § 4332]).

Documenting global emission as part of the EIS process, especially on large infrastructure projects is quite consonant with the overall spirit NEPA. Without clear information about the way in which proposed actions of the federal government influence the global environment, there is an inadequate basis for international decision-making.

Introduction to the Alameda Corridor

The Alameda Corridor is a twenty-mile railway that connects the ports of Los Angeles and Long Beach north to downtown Los Angeles, primarily along Alameda Street. The goal is to create a more efficient way to move cargo inland from the ports to the transcontinental railway east of downtown Los Angeles. (ACTA, 2001).

The estimated cost of the project is over 2.4 billion dollars and the project itself has multiple sources of funding, including both state and federal funds. The bulk of the funding is drawn from state and local financing (a variety of public bonds) backed by railroad use fees, a loan from the U.S. Department of Transportation, grants from the ports of Los Angeles and Long Beach, and federal transit money dispensed through the Los Angeles County Metropolitan Transit Authority. (ACTA, 2001). The large amount and multiples sources of funding are indicative of a high degree of cooperation among both government and private actors. The project has overwhelming support because it is viewed as addressing important needs in the local and national economy.

The main rationale for the ACP is that the two current rail lines used to carry goods from the ports East Los Angeles are almost exclusively at street level. The corridor will eliminate 200 street-level crossings, because it is a trench, built below grade. (ACTA, 2001). This will allow trains to move quickly, easing traffic congestion. Thus, important environmental benefits are cited in the environmental assessments for the ACP because the corridor will result in significant reductions in idling-related train and truck emissions, as well as noise pollution from trains on discontinued routes (U.S. Department of Transportation, 1996). Finally, the ACTA estimates that the project will generate thousands of jobs over the life of the project. These projected benefits are significant, but it is necessary to understand the forces driving the pollution, noise and traffic in the first place.

The ports of Los Angeles and Long Beach, otherwise known as the San Pedro Bay ports, represent the third largest port complex in the world. This is of great importance because "most of the overseas trade flowing in and out of the U.S. passes through the nation's ports. According, to the American Association of Port Authorities, ocean-going vessels move more than 95 percent of all U.S. overseas trade by weight and 75 percent by volume." (Cotrill, 2001, p.16). It is estimated that the amount of cargo shipped by water is expected to triple by 2020. Thus, the San Pedro Bay ports will be under great pressure to accommodate this increased trade while at the same time the already congested freeways of Los Angeles will face additional pressure from truck traffic. About one-quarter of all U.S. waterborne trade depends on the San Pedro Bay ports to reach market. Estimates show the ports will double their current annual cargo load-valued today at more than $157 billion-by 2020. Indeed, in the late 1990s, volumes of containers through the ports grew from 3.2 million a year to more than 7 million. (Flanigan, 2001).

Admittedly, the issues of globalization and international trade are highly controversial, and this paper in no way seeks to claim that trade is a cure all for the ills of the Los Angeles economy. It is clear, however, that Los Angeles and the Southern California region as the gateway to the Pacific Rim cannot afford to ignore the projected increases in trade. The Alameda Corridor is a clear indication that officials have committed the region to being the nation's great port and trade city.

Environmental Justice Analysis

The environmental justice movement is predicated on the belief that communities of color disproportionately bear the burdens of environmental hazards, while the associated benefits are dispersed throughout society. Currently, under the National Environmental Policy Act (NEPA), no regulations have been promulgated that demand that environmental impact reports evaluate federal actions for possible disparate racial impacts. However, in light of the 1994 Executive Order, a new methodology called "environmental justice analysis" is being developed for use with environmental impact reports.

Though environmental justice analysis emerges from a still a burgeoning environmental and social movement dating back to 1980 and, especially the Love Canal incident, its definition is being clarified, and its goals are being defined. The United States Federal Highway Administration claims the fundamental tenet of environmental justice is "To avoid, minimize, or mitigate, disproportionately high and adverse human health and environmental effects, including social and economic effects on minority populations and low-income populations." Others such as Robert Bullard, one of the founders and chief authorities on environmental justice, elaborate on this institutionalized definition. He adds that "any policy, practice, or directive that, intentionally or unintentionally, differentially impacts or disadvantages individuals, groups, or communities based on race or color" is a violation of environmental justice (Bullard in Kevin, 1997, p.126).

Few avenues are currently available to effectively tackle environmental injustice. There are two possible routes: legislation or litigation. Absent Congressional action, the only legal statement consists of President William Clinton's Executive Order 12898 written on February 11, 1994. With Congressional action or the action of state legislature, amendments to NEPA and state environmental legislation, often referred to as "little NEPA's," might be considered. Litigation occurs under both Title VI of the Civil Rights Act of 1964, and the equal protection clause of the XIV Amendment of the United States Constitution.

Current legislation supplies little optimism for environmental justice advocates because NEPA has not been amended to include environmental justice, and state legislation does not yet mandate environmental justice analysis. In fact only fourteen of the fifty states have even enacted "little NEPA's." Much remains to be done on the legislative front.

The largest governmental effort towards environmental justice analysis thus far is the Executive Order. Executive Order 12898 reads in part:

> To the greatest extent practicable and permitted by law…each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States…

Accompanying the Executive Order is an Executive Memorandum, which clearly states that the goals outlined in the above clause should be analyzed "when such analysis is required by the National Environmental Policy Act of 1969." Though the language in this document is strong, President Clinton, in an act demonstrating his Presidential ambivalence on the environment, inserted into the last paragraph of his executive order a provision on judicial review. This clause distinctly explains that the executive order is intended only to "improve the internal management of the executive branch, and is not intended to, nor does it create any…substantive or procedural, enforceable law or equity by a party against the United States…." In essence, this statement declares that the United States will not allow citizens to enforce the implementation of environmental justice initiatives in federal agencies. Instead, programs for environmental justice are directed in a single, fairly vague order, leaving discretion to each individual agency. Executive Order 12898 is largely symbolic in its effect. While it declares that the Federal government recognizes the problem of environmental injustice, it is also makes clear that there is no willingness to assume a proactive role in the fight against it.

Litigation also does not provide the proverbial silver bullet in the struggle against environmental injustice. Title VI of the Rights Act says that "No person in the United States shall on the ground of race, color or natural origin be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program receiving federal financial assistance." The Equal Protection clause of the 14th Amendment says, "No state shall make or enforce any law which shall abridge the privileges or immunities of citizens in the United States." Each of these pieces of legislation is different, but they share the same difficulties in court.

The greatest obstacle to the success of both legislative acts is the ambiguity of such phrases as "disparate impacts" and "disproportionate impacts." Every definition rendered and the executive order issued by President Clinton use one of these two phrases in clarifying environmental justice. Yet, in the thirty years since the conception of the environmental justice movement, an official measure of "disproportionate" has not been created. Therefore, every study and every argument in defense of environmental justice is based upon measures that are arbitrary from a legal standpoint, making effective litigation against environmental inequity very difficult.

The courts have also showed little willingness to extend Title VI and the 14th Amendment to counteract environmental injustice. In 2000, The United States Supreme Court limited the power of citizens to sue under Title VI, which makes successful litigation under it even more difficult. Another provision in Title VI is that it only prohibits actions that cause a disproportionate impact when there is inadequate, non-racial reasoning for the decision. If the defendant is able to prove that they evaluated many alternatives, and determined their course of action based on non-discriminatory criteria, then there is no case against them (Kevin, 1997). The recent limitations imposed by the Supreme Court serve to compound inherent obstacles within Title VI, and effectively make it ineffective as legal tool.

However, it is still easier to win a case under Title VI than it is under the 14th Amendment, because the Supreme Court has ruled that under 14th Amendment, the plaintiff must prove discriminatory intent. The key Supreme Court precedents generally have been applied in the lower courts to mean that unless a defendant has maliciously placed hazardous sites in low income or minority communities; there is no legal remedy available (Kevin, 1997). Because of the extreme difficulty in proving discriminatory intent, litigation under the 14th Amendment has been largely unsuccessful (Fischer, 2001).

In order to mount a case against a government agency or powerful developer, a community must have the money to hire a lawyer, and the ability to galvanize activism. Unfortunately, in low-income and minority communities, there is often little or no ability to muster enough community awareness to form a unified opposition with any political might, or to accumulate enough money to hire a lawyer. Thus, such communities are often easy targets for projects that are associated with negative human health and environmental effects (Kevin, 1997).

Measuring Disparate Impacts

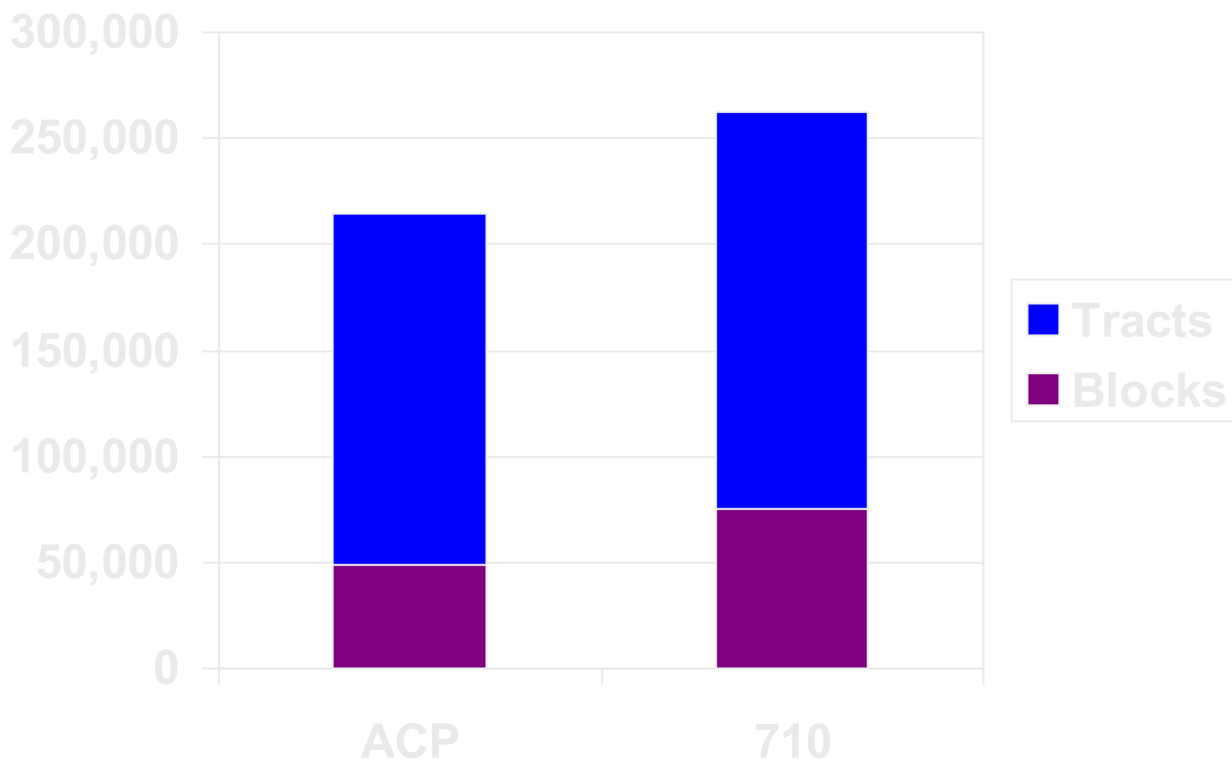
The key to showing whether a project has violated the principles of environmental justice is to demonstrate that groups around the proposed projects will suffer from disparate impacts. The measurement of disparate impacts is highly controversial and proving disparate impacts has been difficult in court.

In the case study, we dealt directly with this problem. First, we had to decide on our comparison groups. We chose the tracts around the 710 freeway, Los Angeles county tracks (LAC), and the tracks in the five-county region. One of the main justifications for the corridor is the projected decrease in truck traffic along the 710. Thus, the corridor constitutes a shift in the burden of pollution from the 710 to the ACP area. Los Angeles and the five-county region were chosen due to the projected economic benefits at the regional level and also due to the estimated decrease in smog at the regional level. Again, there may be a shift in the burden of pollution from regional smog (primarily in the San Gabriel Valley) to localized toxic and particulate pollution in the ACP area.

The next important issue was to decide upon the hypotheses we were to test. Our, three main hypotheses are: 1.) Ethnic and Racial Minorities will be over-represented along the corridor relative to comparison groups. 2.) The corridor area will be working class and relatively poor, and 3.) The corridor area will have fewer resources for political mobilization. Also of note, we used data from the 1990 census for our statistical tests, since we want to base our conclusions upon data that were available to policy makers at the time that the decision was taken as to whether to build the corridor.

The first characteristic we should be aware of is the total population affected by localized pollution as a result of the project. A leading criticism of previous environmental justice studies is that they compared alternatives only looking at the percentages of people affected rather than the total number of people impacted. Clearly, there are a large number of people impacted by the 710 Freeway and the Alameda Corridor Project (ACP) (see Figure 1).

FIGURE 1



Total Population in the Alameda Corridor Project and 710 Freeway Areas

Preliminary analysis of the census data showed insignificant differences across all of the key variables when comparing blocks immediately adjacent to the rail line with their corresponding census tracts. Thus, the study uses tracts as the unit of analysis throughout.

Race

Perhaps the major issue from an environmental justice perspective is whether minority and lower income groups will bear the burden of pollution from the ACP, while the entire region will benefit economically. The 20-mile corridor that runs from the ports into East Los Angeles passes through heavily minority areas. In addressing our hypotheses that ethnic and racial minorities would be over represented around the corridor, we measured the ethnic and racial make-up of our comparison groups. If indeed our hypotheses are correct, the corridor units would have more minorities than the tracts of the 710 freeway, Los Angeles County, and the five-county region.

Results for the test of the racial composition of the area are presented on bar graphs in Figure 2-4. In these figures and the bar graphs that follow below, the x-axis represents the mean percentage of a particular ethnic group in census tracts of a given ACP area, and the comparison groups are placed at varying levels on the y-axis. If this were sample data, the lines extending either direction from the mean would represent a 95% confidence interval. In this case we have data on the total population. Thus, the confidence interval is not strictly necessary, but helps us to draw the conclusion that the differences observed are more than random chance. It is clear that far few whites live around the corridor with a mean of only 4.8% compared to the 710 with a mean of 19% and Los Angeles county and five-county region with means of 43.8% and 51% (see

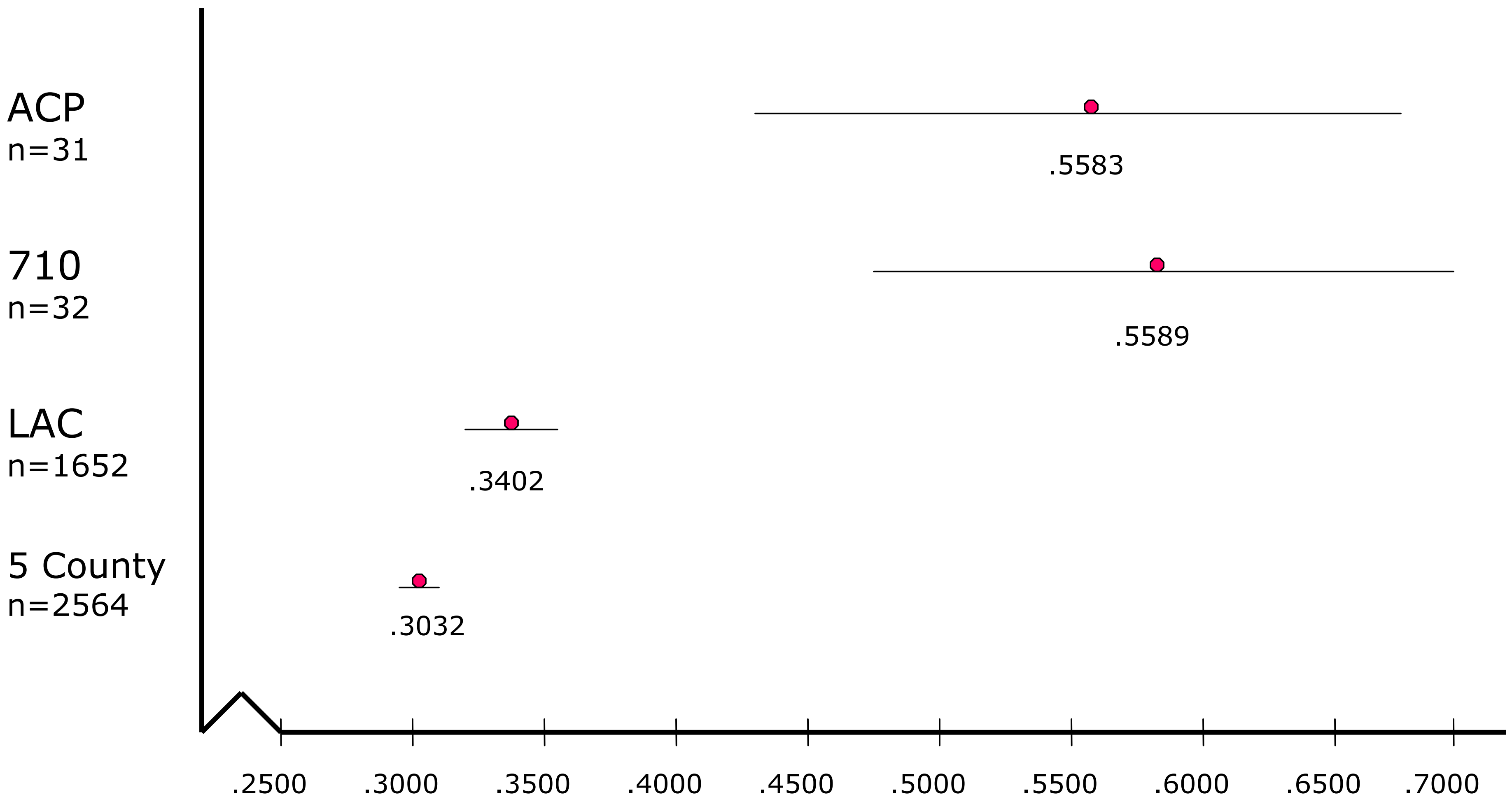
Figure 2).

FIGURE 2

PERCENTAGE WHITE BY COMPARISON GROUPS

FIGURE 3

PERCENTAGE HISPANIC BY COMPARISON GROUPS

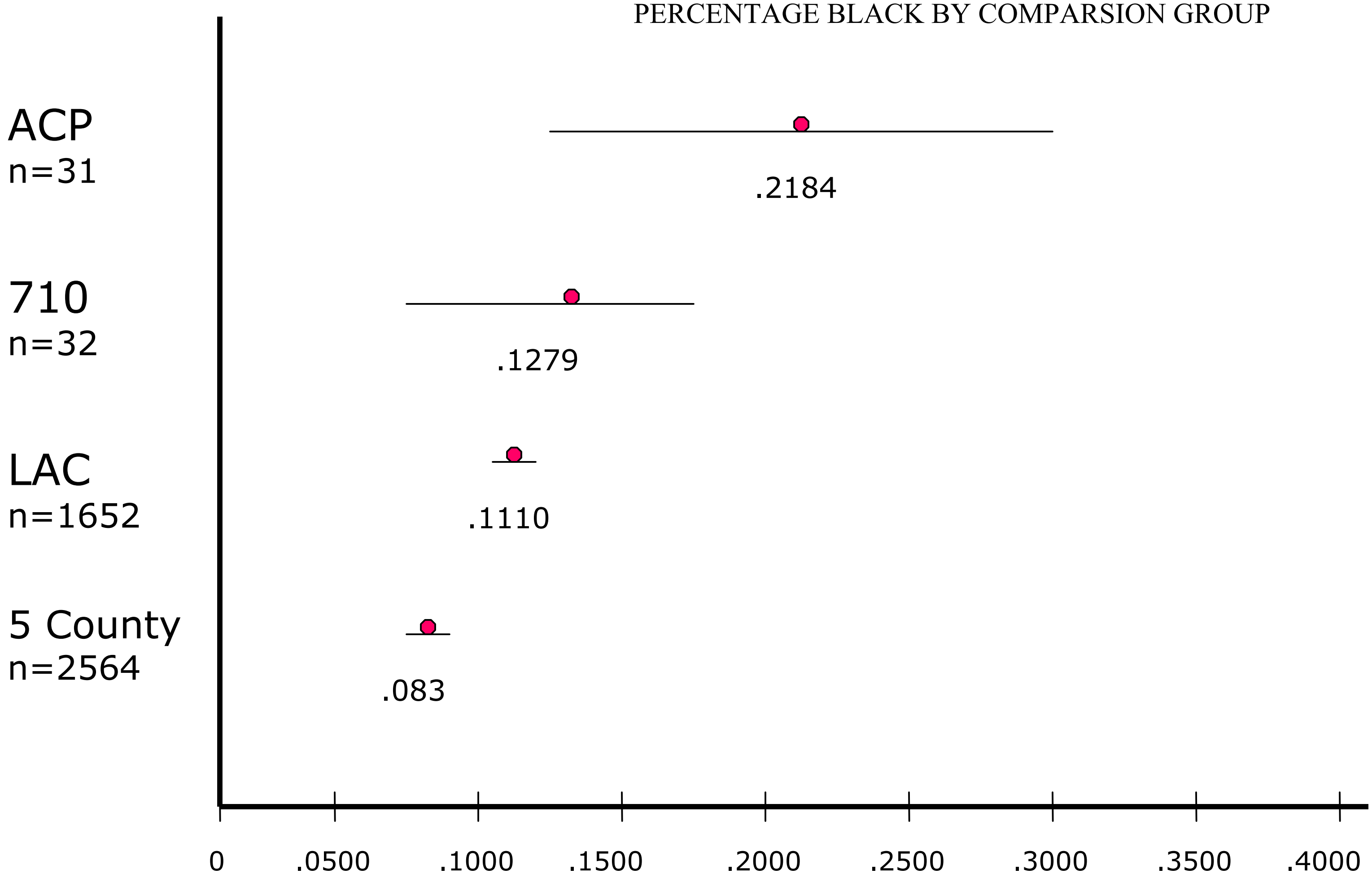


As would be expected, there are also more Latinos along the corridor (mean=55%), than in the LA County overall (mean= 34%) or the five-county region (mean=30%). However, there is an almost equal percentage of Latinos living along the 710 freeway tracks, with the 710 actually having a slightly higher mean Hispanic population (see Figure 3).

Differences between the 710 and the Alameda Corridor tracks arise when we analyze the black population. The tracts around the Alameda Corridor have a mean black population of 21% compared to the 12.7% average for the 710. The key difference between the corridor and 710 is that the 710 has a slightly more whites, while the corridor area has slightly more blacks (see Figure 4). However both areas have far higher mean Latino and black populations than the county or regional track averages.

FIGURE 4

PERCENTAGE BLACK BY COMPARSION GROUP



Class

Using the same strategy of comparing means, we turn to our second hypothesis: the corridor will be far more working class and have higher levels of poverty (see Figures 5-9). Indeed, our hypothesis that the corridor tracts have more poverty is confirmed by the statistics. The Alameda Corridor area has a far lower median family income, a mean of $24,000 compared to the 710 averages of approximately $29,000 and the county and five-county regional averages of close to $40,000 (see Figure 5).

Income is not the only measurement of class. It is also important to consider the relationship of the people to capital itself. One question is whether people in a given area are employed in industries that are resource intensive and/or lead to significant pollution. The environmental justice implication is that certain classes of workers are public-transit dependent, and as such tend to live relatively closer to where they work. Thus, if they depend upon polluting industries for their livelihood, they may be exposed to more pollution on average. Our hypothesis is that the workers along the corridor tend to live close to the manufacturing industries in the area and thus are exposed to higher levels of pollution.

The measurement of employment in polluting industries is derived from the 1990 Census. The scale is from one to seven, with seven being the most polluting. This measurement failed to indicate clear differences between the comparison groups in regards to industry (see Figure 6). If, however, we focus on just employment in manufacturing industry, we notice there are key differences between the areas. The tracks around the 710 freeway and the Alameda Corridor have a greater percentage of manufacturing than the county or five-county regional average (see Figure 7).

Another way to depict class is whether the worker depends on his or her physical labor to make a living. This measure is also scored from one to seven, with one being the most dependent upon physical labor and seven the least. From this measurement it is clear that people along the corridor are far more dependent on their physical labor than those along the 710 freeway, in Los Angeles County or in the five-county region (see Figure 8). Again, if we take a more focused look, differences are even more apparent. One key measure of employment based upon physical labor is the census category, “Operators, Fabricators, and Laborers”. Differences among the comparison groups on this measure clearly demonstrate a higher percentage of blue-collar workers in the ACP area than the county or five-county regional average (see Figure 9). In this case, however, the 710 and the corridor have virtually the same percentage of blue-collar workers.

FIGURE 5

MEDIAN INCOME BY COMPARSION GROUPS

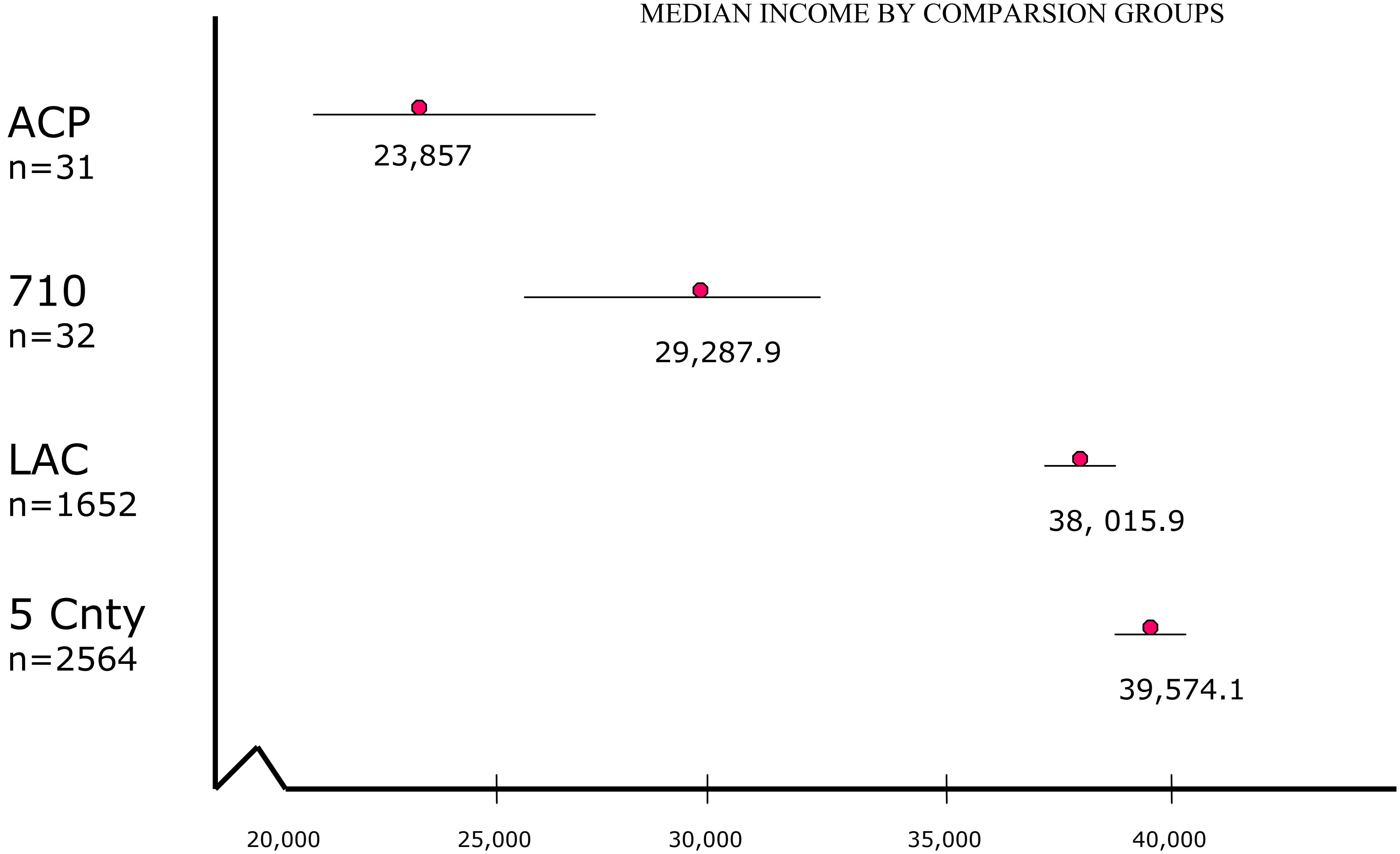


FIGURE 6

EMPLOYMENT IN POLLUTING INDUSTRIES BY COMPARISON GROUP

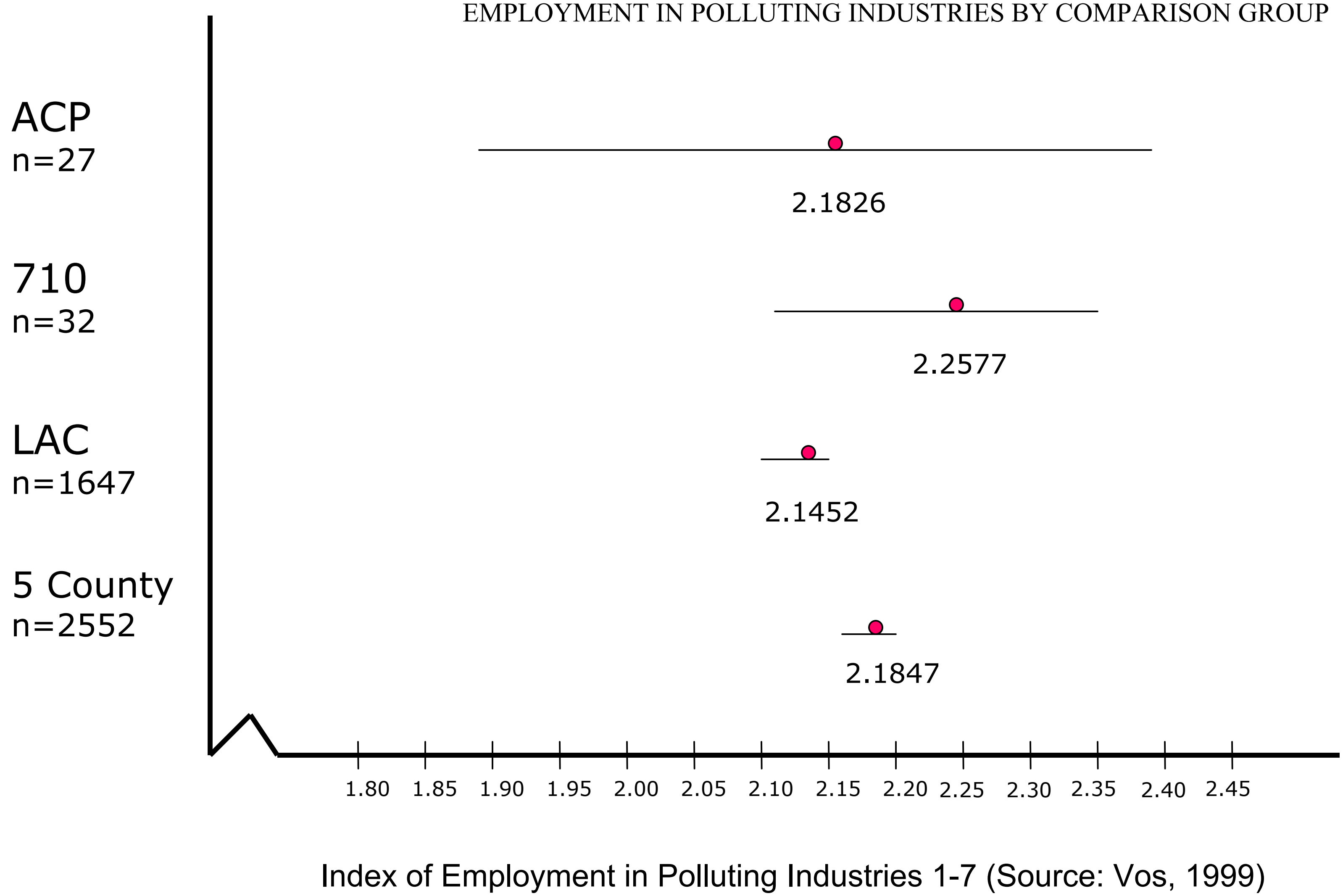


FIGURE 7

PERCENT EMPLOYED IN MANUFACTURING BY COMPARISON GROUPS

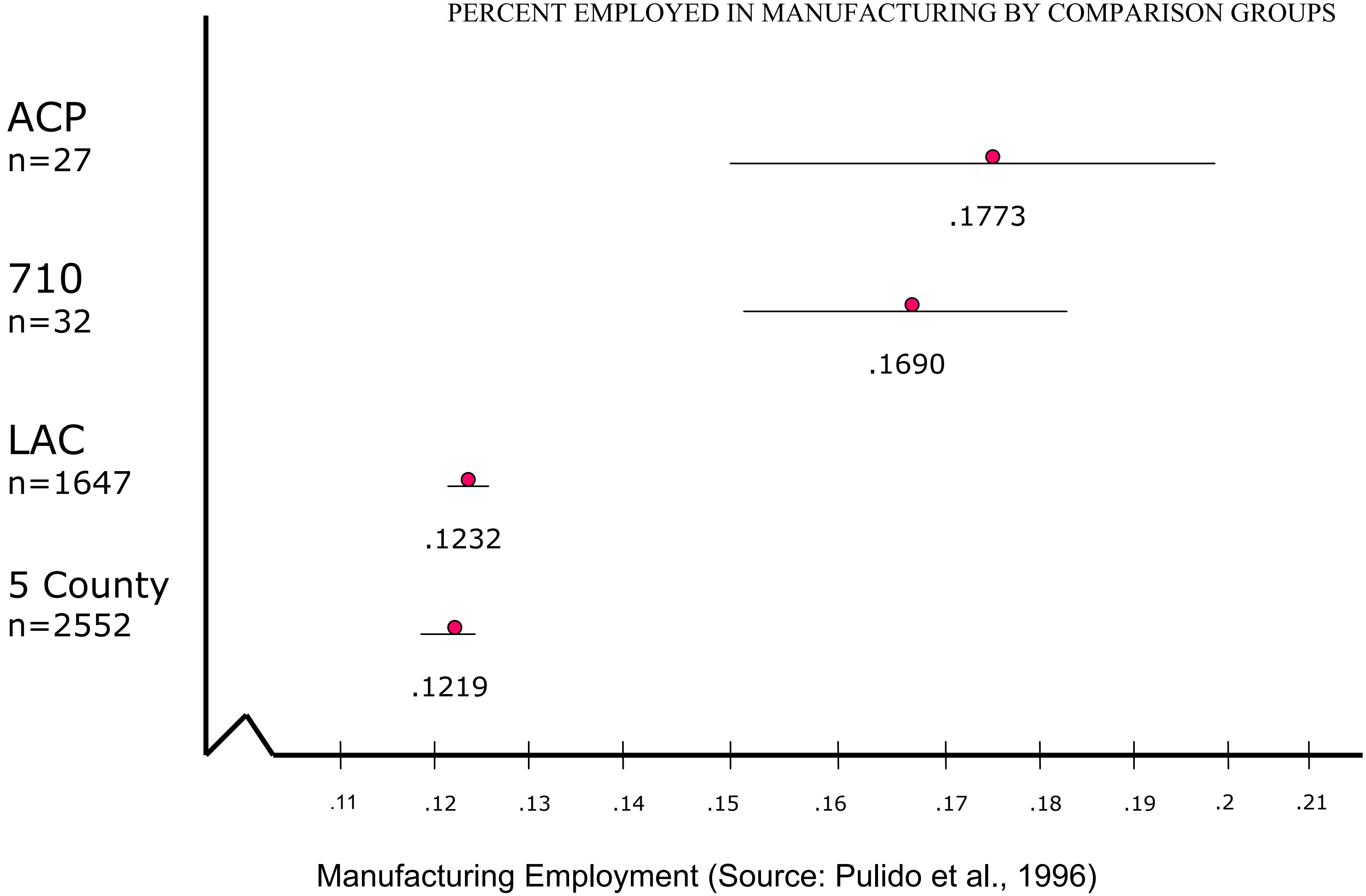


FIGURE 8

BLUE COLLAR OCCUPATION BY COMPARISON GROUPS

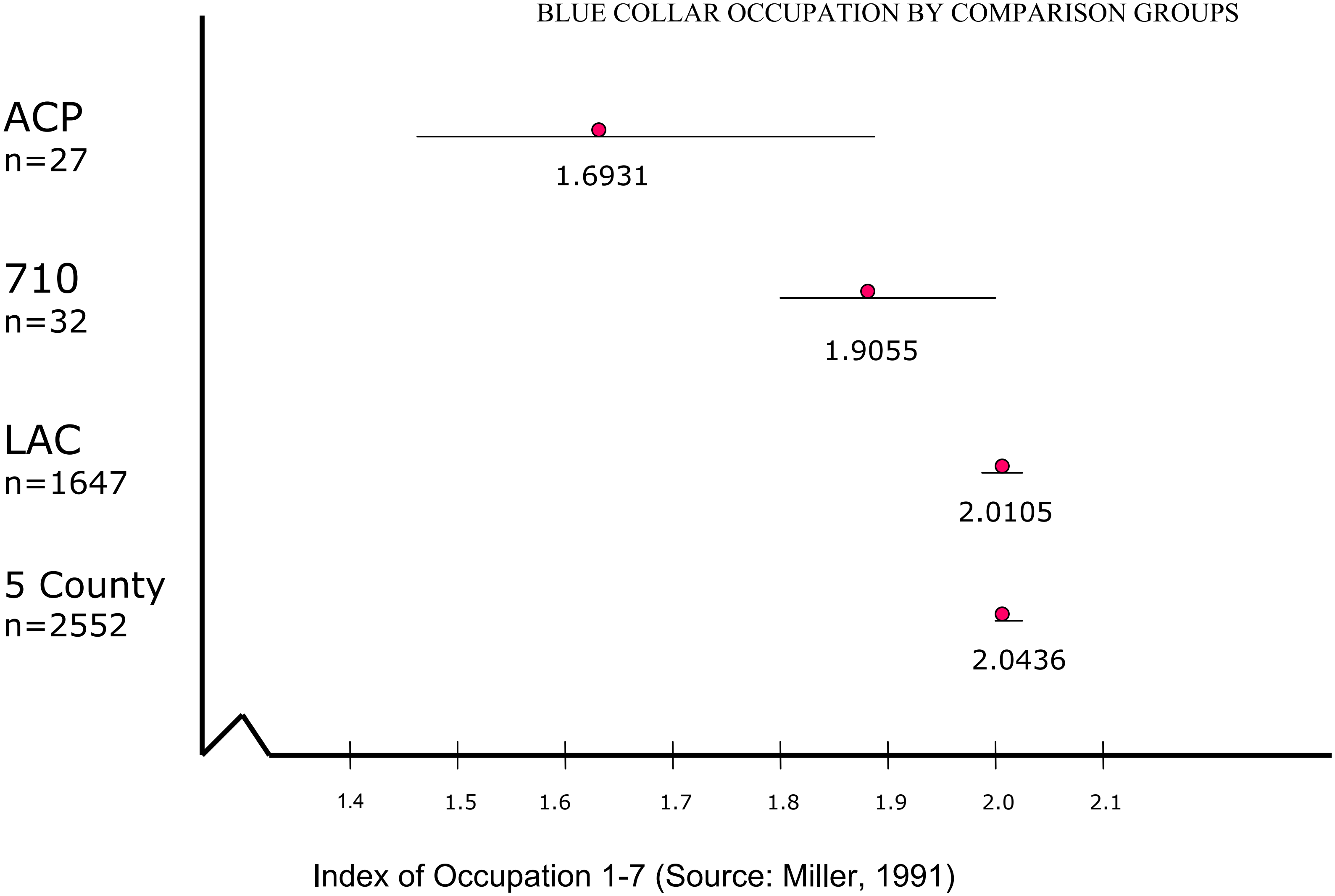
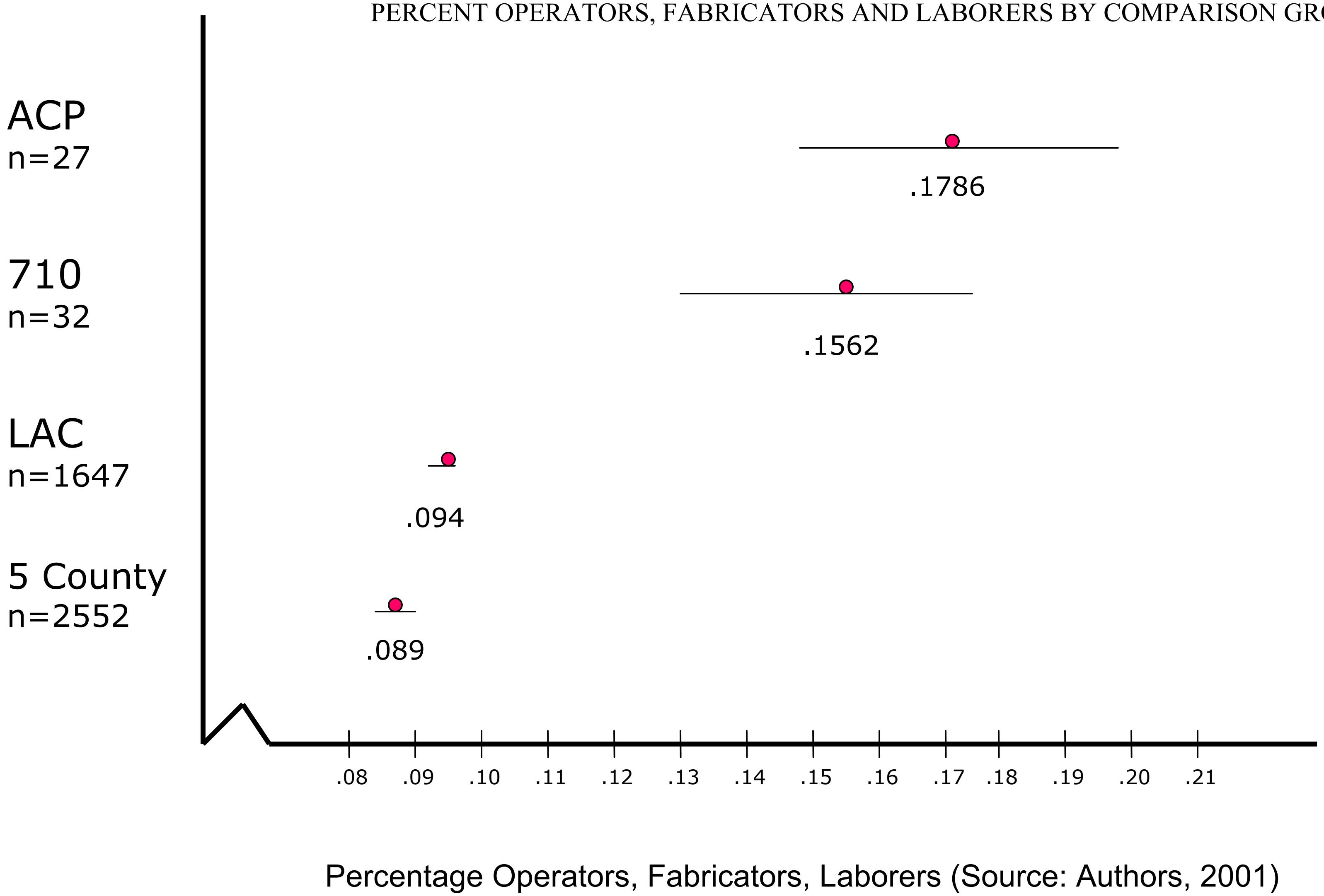


FIGURE 9

PERCENT OPERATORS, FABRICATORS AND LABORERS BY COMPARISON GROUPS



Political Mobilization: Education and Diversity

One leading theory of environmental injustice is that minorities and underprivileged groups are forced to bear a disproportionate burden due to their limited political mobilization. It is our hypothesis that this lack of mobilization is owed, at least in part, to the limited education of the groups in question. It is well known that less educated publics have difficulty taking part in complex policy arenas, and tend to vote less.

Thus, if we take a look at educational achievement it is not surprising that both the corridor and 710 Freeway would have the lowest mean educational achievements (see Figure 10). The measurement utilized here runs on a seven-point scale, where a score of three indicates high school graduation. Around the 710 Freeway and corridor we see that the mean educational achievement is below that of high school graduation.

An emerging theory of environmental justice also argues that communities that are ethnically diverse will have a difficult time organizing politically. In communities undergoing ethnic transitions or with diverse ethnic groups, it may be less likely that people will unite against unpopular public works projects, due to the difficulty of crossing ethnic and racial lines. However, we found the opposite (see Figure 11). The tracks around the corridor were the least diverse tracks in our comparison groups. The earlier findings were based on waste disposal facilities and the same relationship may not hold true for large infrastructure projects.

FIGURE 10

EDUCATIONAL ATTAINMENT BY COMPARISON GROUPS

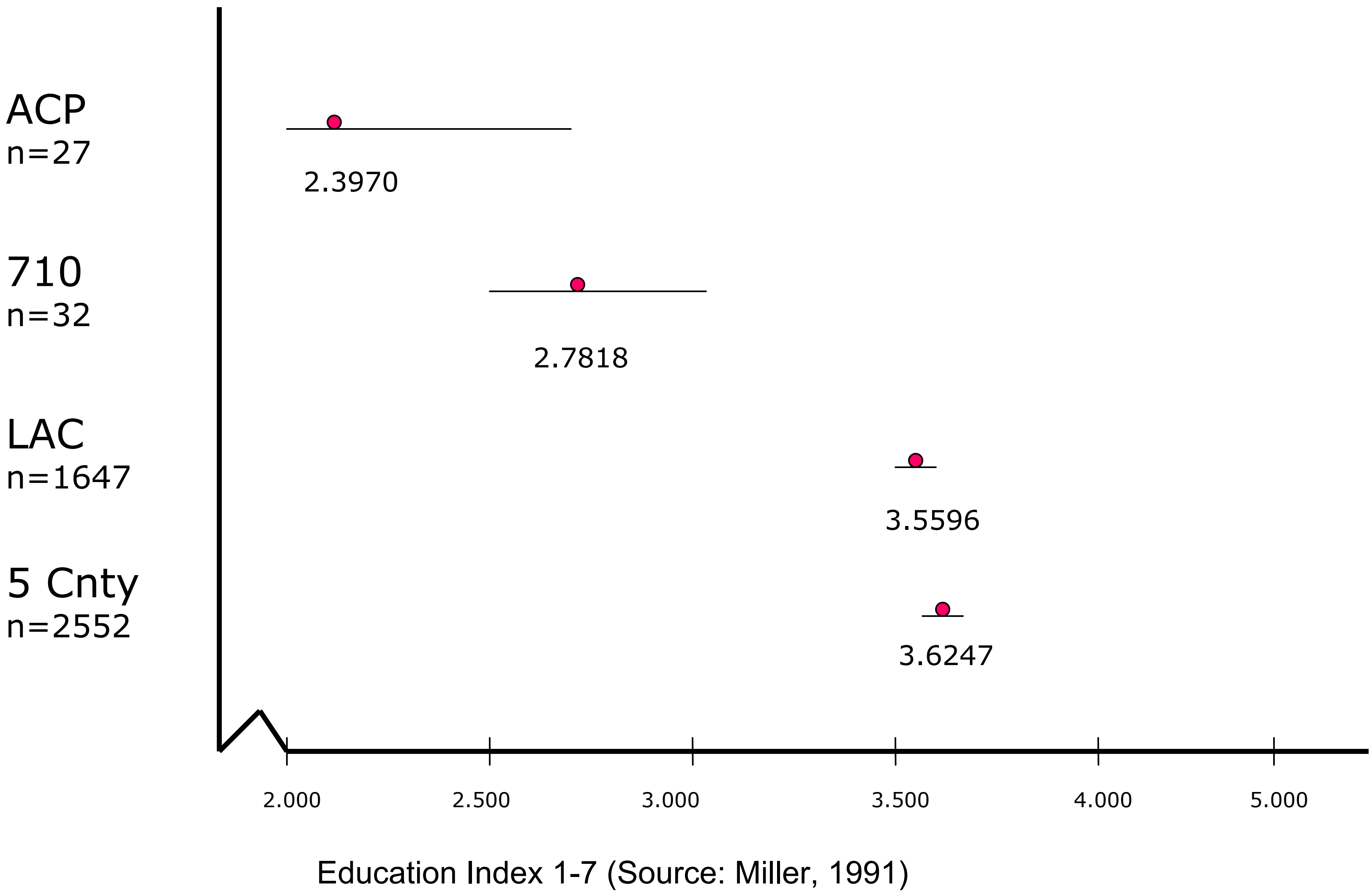
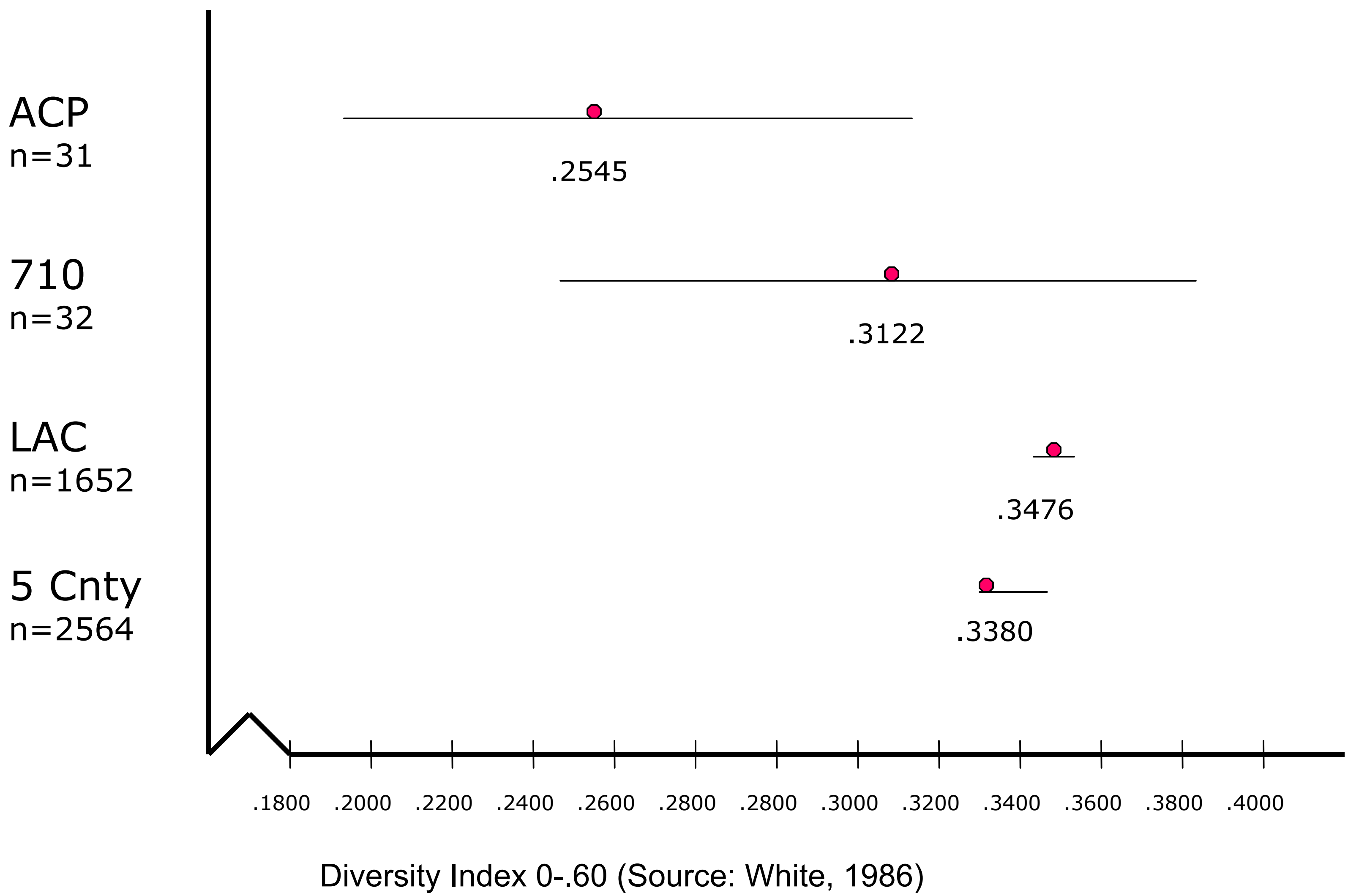


FIGURE 11

RACIAL AND ETHNIC DIVERSITY BY COMPARISON GROUPS



Cumulative Impacts

An important and often overlooked component in environmental impact assessment is the examination of cumulative impacts. The most harmful environmental effects may result not from the direct effects of a particular action, but from the combination of new pollution with existing sources of pollution, or inducement of multiple actions that either increase or concentrate pollutants over time. The ACP project brings with it the risk of both of these types of cumulative impacts. On the one hand, there is the impact of diesel exhaust on existing public health problems in an area that already has a "hot spots" of toxic air pollution. On the other hand, the corridor may induce the growth of trucking and warehousing in the area, a "logistics industry" that brings new pollution along with it.

It is important to identify pre-existing public health burdens on surrounding communities. Any additional pollution attributed to the project must be put into the context of absolute exposure levels to fully understand potential health effects. The growth of the logistics industry could lead to the increased prevalence of diesel-emitting vehicles, further exacerbating the cumulative effects of air pollution upon the neighborhoods surrounding the Alameda Corridor.

Cumulative effects can be attributed to single or multiple actions and may result in additive or interactive effects. Interactive effects can be further classified as either countervailing, where the net adverse cumulative effect is less than the sum of the individual effects, or synergistic, where the net adverse cumulative effect is greater than the sum of the individual effects (CEQ, 1997, 8). Assuming that the effects of diesel exhaust are merely additive may underestimate the total effective human risk if one or more of the components operates synergistically to magnify the cancer risk.

A principal concern in regards to the ACP is the amount of diesel exhaust it will add to the surrounding neighborhoods due to frequent operation of diesel locomotives. Diesel exhaust is a complex mixture of gases and fine particles emitted by internal combustions engines that are fueled by diesel. Because of incomplete combustion, the waste gases contain such pollutants as carbon monoxide, sulfur oxides, nitrogen oxides, volatile organics, alkenes, aromatic hydrocarbons, and aldehydes. According to a report on diesel exhaust by the California Air Resources Board (CARB) Scientific Review Panel, diesel exhaust is characterized by a significantly higher rate of particle emissions as compared with gasoline-fueled engines (Scientific Review Panel, 1998, p.3).

Diesel exhaust includes more than 40 substances that are listed by the United States Environmental Protection Agency as hazardous air pollutants and by the California Air Resources Board as toxic air contaminants (Scientific Review Panel, 1998, p.4). Of these, the International Agency for Research on Cancer (IARC) has listed fifteen substances as probable or possible human carcinogens. These substances include: acetaldehyde; antimony compounds; arsenic; benzene; beryllium compounds; bis (2-ethyldexyl) phthalate; dioxins and dibenzofurnans; formaldehyde; inorganic lead; mercury compounds; and styrene (Scientific Review Panel, 1998, p.4).

Particulate matter (PM10) consists of various solid particles and liquid droplets less than ten microns in diameter that are suspended in the air. Some of these particles, made up of asbestos, chromium, nickel, arsenic, and lead, are themselves highly toxic. Other particles are health risks because they can harm the lungs. Both coarse (PM 10) and fine particles (PM 2.5) affect health, but fine particles are the most dangerous. Fine particles cause more harm because they can bypass the body's defenses and penetrate deeply into the lungs, enter indoors, and remain suspended in the air for longer periods of time.

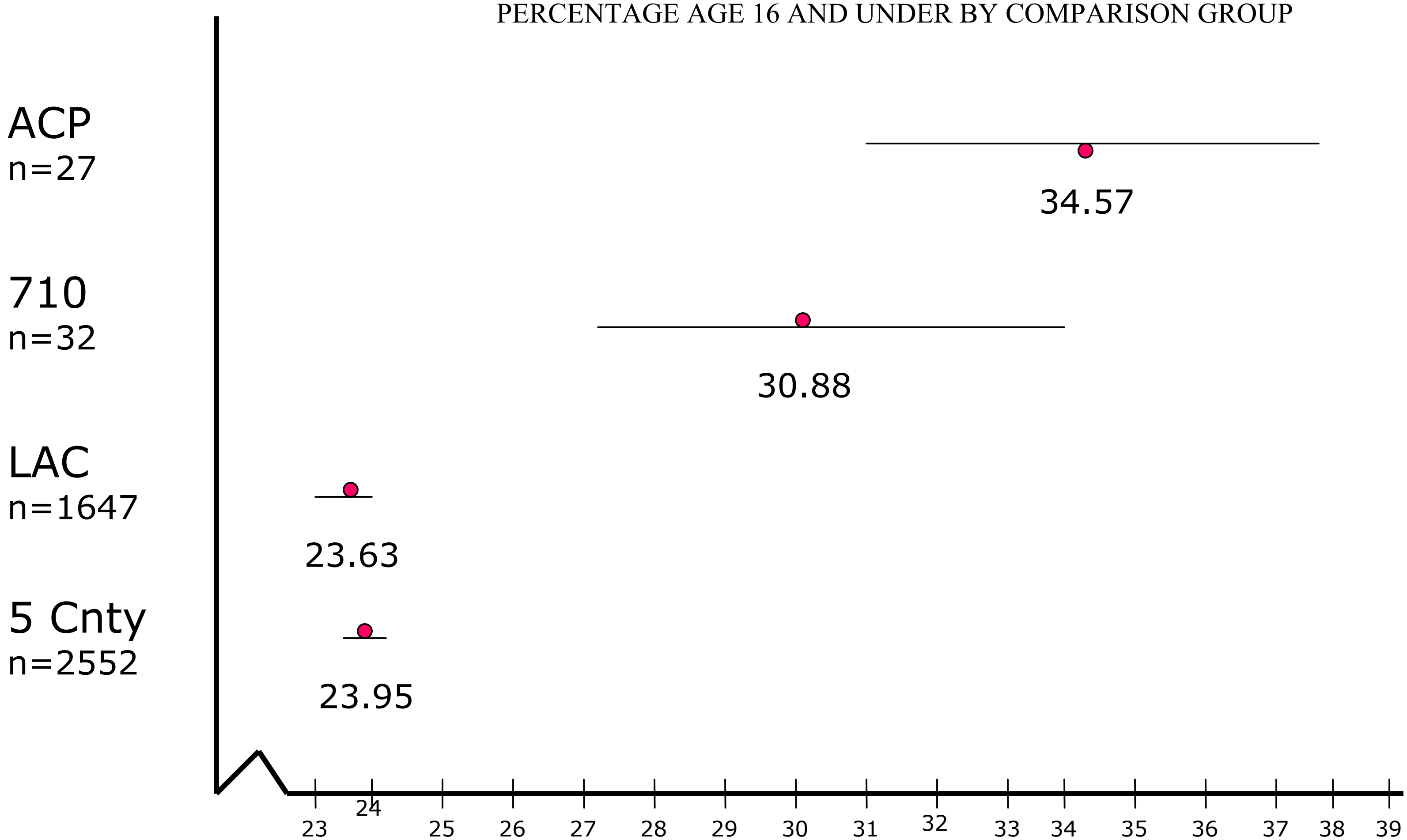
The prevalence of ultra fine particles may actually be increasing over time. A 1996 study by the Health Effects Institute showed that despite a substantial reduction in the weight of total particulate matter, the total number of particles from a 1991-model engine was 15 to 30 times greater than the number of particles from a 1988-model engine, when both engines were run without emissions control devices (Health Effects Institute, 1996). Ironically, the fine particles, which are the most important health concerns, could be formed as a result of newer technologies.

Preliminary Findings on Cumulative Impacts

Unfortunately, no detailed source of existing rates of respiratory disease in the area could be located. However, the population in the ACP area was found to be substantially younger than the comparison groups. This is a significant finding since youth itself is a major risk factor in developing respiratory disease from air pollution. The percentage of residents younger than age 16 was calculated for each population using 1990 census data. Tracts in both the Alameda Corridor and the 710 Freeway area have significantly higher percentages of children aged 16 or younger than Los Angeles County or the region as a whole (see Figure 11).

FIGURE 11

PERCENTAGE AGE 16 AND UNDER BY COMPARISON GROUP



The Multiple Air Toxics Exposure Study (MATES-II), an urban toxics monitoring and evaluations study conducted by the South Coast Air Quality Management District (SCAQMD) in 1998-1999 found that sites with the greatest levels of risk were in the south-central and east-central parts of Los Angeles County (SCAQMD, 2000, ES-5), areas that include the Alameda Corridor. At these locations, dominance of mobile emissions sources was higher than other areas in the South Coast Basin (SCAQMD, 2000, 7-3).

Medical studies have shown that the exacerbation of asthma by diesel exhaust particles significantly affects children. Children have higher rates of asthma than do adults, and asthma attacks are more serious in children due to their smaller airways (OEHHA, 2001, 2). Children consume three times as much air per body weight as adults (Mann, 1991, 21-22). Moreover, children spend a greater amount of time outdoors than adults. They are especially vulnerable because their respiratory, pulmonary, and immunological functions are still developing. Studies have shown that diesel exhaust particles can induce immunological reactions and aggravate allergic responses. Thus children are disproportionately affected by diesel exhaust. Because populations along the Alameda Corridor are disproportionately young, environmental justice would dictate that additional air pollution burdens placed upon these neighborhoods would have disproportionate impact and should be taken into careful consideration.

The other instance of cumulative impact examined in this study is the presence and possible growth of the logistics industry induced by the ACP. The logistics industry is comprised of businesses involved in the movement of goods and services, such as trucking and warehousing firms. We hypothesized that the logistics industry would grow in anticipation of the Alameda Corridor's operation. This would in turn lead to higher than officially projected traffic and diesel emissions. Measures of the number of businesses associated with the logistics industry in Los Angeles County were developed by selecting standard industrial classification (SIC) codes that are related to logistics industry and then creating a dataset to depict the number of logistics firms by zip code-area.[1]

One initial finding is that the distribution of the number of firms is heavily weighted to the left, which signifies that many zip codes in Los Angeles County have no logistics firms at all. The evident and severe spatial concentration of the logistics industries in Los Angeles County is indicative of a potential problem with environmental injustice. In fact, areas along the proposed Alameda Corridor have significantly higher concentration of logistics firms than Los Angeles County as a whole. Thus, the residents along the Alameda Corridor Project are situated closer to disproportionately dense logistics activity and its accompanying pollution, traffic, and noise compared to Los Angeles County in general.

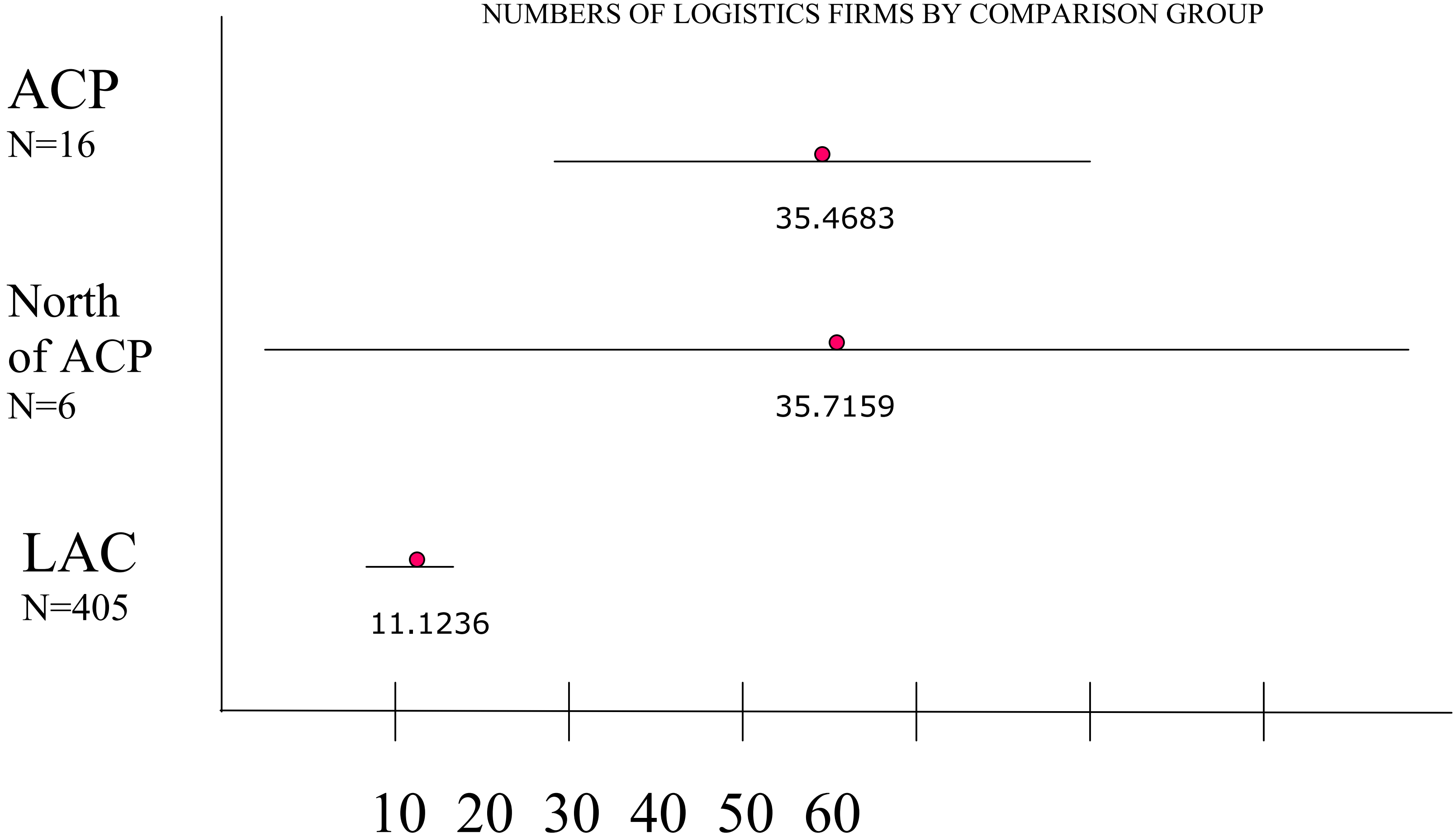
We also hypothesized that the areas just past the northern end of the ACP would have more logistics industries as the ACP prepares to open. The proximity of the area to the termination of the ACP, and opportunities to shift cargo onto freeways and rail lines in eastern Los Angeles would seem to make this an attractive area for logistics firms to locate. Comparisons were made between zip codes along the Alameda Corridor, and areas just North of Alameda Corridor (see Figure 12). Existing evidence does not

[1] Standard Industrial Codes 4011,4013, 4212-4214, 4221, 4222, 4225, 4226, 4449 (Source: I-Market Business Information Services, 2001): I-Market Business Information Services, 2001)

support this hypothesis. There was no statistically significant difference between zip codes along the Alameda Corridor and zip codes just north of it in terms of concentration of logistics industries. Zip codes along the Alameda Corridor had a statistical mean of 35.5 logistics firms, while those north of the northern-most end of the corridor have statistical means of 35.7

FIGURE 12

NUMBERS OF LOGISTICS FIRMS BY COMPARISON GROUP



Selected Standard Industrial Classification (SIC) Codes
Source: I-Market Business Information Services, 1996-2001)

Unfortunately, we were unable to depict the volume of business and sales due to missing data. Incomplete data also makes it impossible to reliably depict trends in the growth of the logistics industry over time. It is possible that the ACP already has, or may induce growth in the logistics industry in the corridor area when it opens, but a new method must be developed, or new data must be found to test this hypothesis.

Conceptual Framework for Life-Cycle Assessment

Life-Cycle Assessment (LCA) is an analytical and comparative science used to evaluate environmental impacts relating to the whole production chain of a good. Unlike currently employed technologies in the environmental assessment industry, LCA accounts for the cumulative impact of products, the global, regional and local effects of a product, as well as the ultimate disposal or reuse of a product. The goal of LCA is to compare the possible environmental effects of all feasible alternatives, and then to implement the most environmentally friendly alternative.

A four-step methodology has been created for LCA studies. The first stage is called "goal scope and definition." During this preliminary step, it is determined what materials will be assessed, what alternatives will be examined, and the possible limitations of the study are explored. The first stage gives way to the second named "life-cycle inventory analysis." It is at this point in the study that quantitative models are used to calculate the amount of energy and raw materials that will be used in the project, and the amounts and kinds of environmental waste and pollution that will be produced. The subsequent step is called "impact analysis." In impact analysis, the raw data derived from stage two is translated into possible environmental effects, and the impact or burden they may have on the external world. The final stage is "improvement assessment." In improvement assessment, stages one two and three are analyzed and compared in order to draw conclusions as to which alternative is the most favorable (Graedel, 1998, 23).

In a large project such as the Alameda Corridor, the LCA must take into account numerous factors, including both construction and operation. Since both phases of the project will produce harmful emissions it is necessary to include them in the final analysis. Of particular importance are interactions with the larger global system that will support the ACP. For example, emissions from throughout the fuel-cycle, and not just at the point of exhaust discharge from the locomotive. Also to be taken into consideration are reduced levels of use in other parts of the transportation system, especially truck traffic on local freeways, and the impacts that run behind the maintenance and operation of this surface transportation system (see Figure 7, vehicular activity).

FIGURE 13
PROPOSED OUTLINE OF ALAMEDA CORRIDOR PARTIAL LIFE-CYCLE INVENTORY (LCI) ANALYSIS[1]

Activity/LC Phase:	Assessed Impacts:	Data Sources:	Non-Assessed Impacts:
CONSTRUCTION			
- EQUIP. MAINT.	- Direct air emissions (criteria and TRI pollutants only)	- EIOLCA[2] ($ estimated based on hrs. operation)	- Other emissions, effluents, wastes, inc. life-cycle chain - Material/energy inputs, inc. life-cycle input chain
- FUEL CONSUMPTION			
↑ FUEL PRODUCTION	- Direct air emissions (criteria and TRI pollutants only)	- EIOLCA and DeLuchi (1993) (fuel quantities from EIR)	- All other life-cycle impacts of fuel production
- EQUIP. EMISSIONS	- CO_2 emissions - Criteria pollutants - HAPs	- Estimated from fuel consumption. - EIR data - Constituents of ROG, PM (composition, fraction from lit. data for diesel exhaust)	
- RAW MATERIAL INPUT	- Not considered		- All life-cycle impacts of material production
- WASTES, END-OF LIFE DISPOSITION	- Not considered		-Construction/ demolition waste not primarily air pollution related.

(1) Calculated for "no project" and "Alternative 1." Life-cycle impacts considered are limited to those of interest (air emissions) and/or those, which would be expected to be significantly different among alternatives and/or those for which data is available. In particular, the "no project" alternative includes greater Vehicle Miles Traveled (VMT's) from all sources; and, the analysis is intended to capture the life-cycle consequences of this.

(2) All EIO-LCA impacts based on $-value, which must be determined on some basis. With dollar values, data can be estimated from the input-output software under development at Carnegie Mellon University (www.eiolca.net).

RAIL ACTIVITY

- MAINTENANCE rail line rail cars locomotive engines	- Direct air emissions (criteria and TRI pollutants only)	- EIOLCA ($ estimated based on EIR VMT)	- Other emissions, effluents, wastes, inc. life-cycle chain - Material/energy inputs, inc. life-cycle input chain
- FUEL CONS.			
FUEL PROD.	- Direct air emissions (criteria and TRI pollutants only)	- EIOLCA and DeLuchi (1993) (fuel quantities from EIR)	- All other life-cycle impacts of fuel production
- OPERATING EMISSIONS[(3)]	- CO_2 emissions - Criteria pollutants - HAPs	- Estimated from fuel consumption. - EIR data and fuel consumption. - Constituents of ROG, PM (composition, fraction from extant data in the literature on diesel exhaust)	
- TRAIN PRODUCTION	- Not considered		- All life-cycle impacts of train production, including precursor stages, e.g., raw material prod., embedded energy and its prod.
- END-OF LIFE DISPOSITION	- Not considered		

(3) EIR-reported emissions are presumed to be based on anticipated modal conditions; and, no further adjustment is made. Calculation of dependent quantities (CO_2, HAP quantities) based, typically, on aggregate/average conditions and fleet composition.

VEHICULAR ACTIVITY

- OPERATING EMISSIONS(3)	- CO_2 emissions - Criteria pollutants - HAPs	- Estimated from fuel cons. - EIR data and fuel cons. - Constituents of ROG, PM (composition, fraction from lit. data for diesel exhaust and gasoline exhaust)	
- MAINTENANCE truck automobile freeway surface streets	- Direct air emissions (criteria and TRI pollutants only)	- EIOLCA ($ estimated based on EIR VMT)	- Other emissions, effluents, wastes, inc. life-cycle chain - Material/energy inputs, inc. life-cycle input chain
- FUEL CONS.			
FUEL PROD.	- Direct air emissions (criteria and TRI pollutants only)	- EIOLCA and DeLuchi (1993) (fuel quantities from EIR)	- All other life-cycle impacts of fuel production
FUEL DIST.	- Direct air emissions (criteria and TRI pollutants only	- Est. VMT associated with above quantities of fuel, i.e., for delivery to gas stations - Avg. emission rates for trucks	- Other life-cycle stages assoc. with distribution, e.g., vehicle production.
FUELING FUGITIVE EMISSIONS	- VOCs (ROG emissions) - HAP emissions	- Above fuel quantities - Regulatory limit for fueling fugitive releases (i.e., for release quantity) - HAPs from data on fuel composition	
- VEHICLE PRODUCTION	- Not considered (although this is proportional to VMT)		- All life-cycle impacts/stages associated with vehicle prod.
- END-OF-LIFE DISPOSITION	- Not considered		

Conducting an actual life-cycle inventory, even on just the air pollution components of the ACP, was beyond the scope of the work for this preliminary research. Instead, a proposed outline for such a partial life-cycle inventory was produced (also, see Figure 13). This outline identifies impacts and data sources for the air pollution aspects of the ACP. The identification of data sources describes the sort of "demand data" and methods of translating demand data to impact data that would be used. The outline is divided into three activity phases: ACP construction activity, vehicle activity, and rail activity. Within each activity phase, air pollution emissions are traced from production, maintenance and operation. Because new urban infrastructure developed for the ACP is, at least for the foreseeable future, a permanent development in the urban landscape, the end-of-life, product disposition phase is not considered in this analysis. Air pollution emissions from whatever disassembly or reuse of the corridor might someday occur are simply too speculative to estimate.

Alternative Fuel Technologies and Improvement Assessment

The environmental impact assessments completed for the Alameda Corridor claims that its construction will reduce emissions of criteria air pollutants in the Los Angeles air basin by eliminating many of the trucks that currently run from the ports to downtown, and through the use of a centralized, below grade, freight corridor that will alleviate idling of truck and automobile traffic (U.S. Department of Transportation, 1996). While the emissions of air pollutants on a regional scale may well be reduced, exposure to air pollutants in the immediate vicinity of the corridor seems likely to increase. One effective way to ease such harmful exposures is through the use of alternative fuel technologies (see Figure 14).

FIGURE 14: ALTERNATIVE TRAIN FUELS

FUEL	How it Works	Advantages	Disadvantages	Technological Feasibility	Application Feasibility
Fuel Cell	Hydrogen runs through an anode catalyst where it is split into one proton, and one electron. The electrons are used for electricity before they are reunited with protons and oxygen to form water.	♦ Zero Emissions ♦ Quiet ♦ Efficient ♦ Extremely Durable ♦ Long Lasting ♦ Provide Energy Security	♦ Infrastructure for refueling and building not in place ♦ Expensive ♦ Hydrogen poses safety risks ♦ Hydrolysis to separate hydrogen is inefficient	After the Year: 2015	Excellent
Electric	Power lines hung from the crossbars of the corridor provide electrical power to the locomotive.	♦ Zero Emissions ♦ Quiet ♦ Refueling is unnecessary	♦ Very expensive ♦ So. Cal. has electricity generation problems ♦ Electricity is not strong enough to pull heavy loads	After the Year: 2010	Not Probable
Ethanol	Made from plants and agricultural leftovers that are converted to sugars and fermented to form ethanol.	♦ Burn more cleanly and completely ♦ Eliminates most criteria pollutants ♦ Potentially renewable ♦ Provide energy security ♦ Creates new market for farmers	♦ May diminish food supply for Americans or foreign aid ♦ Not strong enough to pull heavy loads ♦ Requires large amounts of land for production ♦ Expensive	After the Year: 2012	Not Probable
Bio-Diesel	Made from the mixing of edible plant oils, or oils derived from animal fats with alcohol, to create more useful oils.	♦ Potentially sustainable ♦ Low sulfur content ♦ Low tailpipe emissions ♦ Runs in conventional diesel engine ♦ Delivers similar performance to petrodiesel ♦ Provides energy security	♦ Requires food for fuel ♦ Doesn't eliminate NOx ♦ Does not function as well completely independent of petrodiesel ♦ Exhaust smells like French fries	Currently Available	Excellent
Comp. Natural Gas (CNG)	CNG is held on board in storage tanks and then burned in order to run a modified diesel or gas turbine engine.	♦ Readily available ♦ Relatively Clean ♦ Cheap to operate ♦ Reduces NOx by over 99% ♦ Eliminates particulate matter ♦ Very efficient ♦ Provides some energy security	♦ Very little infrastructure currently in place ♦ Not compatible with current locomotive engines ♦ Possibly dangerous (explosive)	After the Year: 2007	Good
Comb. Cycle Loco.	CNG powers an engine, and the heat generated by combustion is channeled to boil water and create a CNG\Steam hybrid.	♦ Steam provides a lot of extra power ♦ Enables high fuel efficiency ♦ Burns Clean ♦ Cost effective	♦ See above for CNG ♦ Steam boiler requires constant cleaning ♦ Large plumes of steam not suitable for cities	After the Year: 2012	Good

Many alternative fuel technologies exist today, yet will not be used in the Alameda Corridor at its inception, nor were they considered as alternatives in the initial environmental impact assessments. For many fuels such as electricity, the problem is cost. For others such as fuel-cell locomotives, the technology does not exist and the infrastructure is not in place. Nevertheless, other fuels such as bio-diesels were not considered, though they are a feasible alternative, because they are generally economically efficient and readily available as a fuel source. In Figure 8, we have identified six alternative fuel technologies that would alleviate the impacts of hazardous air pollutants from diesel exhaust on the local scale. However, each of these fuels must be put through a life-cycle assessment of its own in order to explore effects at the global and regional levels, and to ascertain that the production impacts of such fuels does not outweigh their local benefits.

Conclusion

Environmental impact assessment techniques like environmental justice analysis and LCA can be beneficial for use in legally mandated assessment of major urban infrastructure projects. They would allow for more informed decision-making, and better strategies for mitigation. The advantages of LCA are clear when evaluating such complex matters as which fuel to use to power the mighty locomotives in the Alameda Corridor. Similarly, environmental justice analysis ensures that the siting of large urban infrastructure projects and other environmentally harmful undertakings will be fair and the burdens more evenly distributed throughout the nation.

Yet both environmental justice and LCA are fledgling fields of study still searching for their wings. A methodology must be created for addressing environmental justice analysis that will allow us to clarify "disparate" and "disproportionate" impacts. LCA must become cheaper and easier to complete. Currently, very few engineers are trained in LCA, and so LCA would be expensive for governmental agencies to use, and they are unlikely to immediately adopt it in environmental impact assessment. LCA will not become a reality unless it is efficient and economically feasible. Further research is necessary both to demonstrate the effectiveness of such measures and provide efficient means for government agencies and their consultants to use such techniques. To achieve greater environmental protection, LCA and environmental justice analysis need to be implemented expeditiously in future Environmental Impact Reports, especially those pertaining to large urban infrastructure projects such as the Alameda Corridor.

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