COPY

**Case No. S213478**



**IN THE SUPREME COURT OF CALIFORNIA**

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**CALIFORNIA BUILDING INDUSTRY ASSOCIATION**
**Plaintiff and Respondent**

**vs.**

**BAY AREA AIR QUALITY MANAGEMENT DISTRICT**
**Defendant and Appellant**

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# CALIFORNIA BUILDING INDUSTRY ASSOCIATION'S SUPPLEMENTAL MOTION FOR JUDICIAL NOTICE; DECLARATION OF ANDREW B. SABEY & [PROPOSED] ORDER

After a Decision by the Court of Appeal in a Published Opinion
First Appellate District, No. A135335 & A136212

On Appeal from a Judgment
Alameda County Superior Court, No. RG10548693
Honorable Frank Roesch, Judge of the Superior Court

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Pursuant to California Evidence Code Sections 452 and 453, Plaintiff and Respondent California Building Industry Association ("CBIA") hereby requests that the Court take judicial notice of the exhibits identified below, offered in support of its Joint Answer to Amici Briefs. The authenticity of the exhibits is established through the declaration of Andrew B. Sabey, which is attached hereto as Exhibit M.

Exhibits H through L are relevant to the interpretation of the California Environmental Quality Act (CEQA) and to rebut the factual assertions made by Amici.

These documents were not presented to the trial court because they are being relied on to rebut arguments made after judgment was entered.

Judicial notice may be taken of the "[o]fficial acts of the legislative, executive, and judicial departments of . . . any state of the United States." (Cal. Evid. Code § 452(c).) The Court may judicially notice "[f]acts and propositions that are not reasonably subject to dispute and are capable of immediate and accurate determination by resort to sources of reasonably indisputable accuracy." (Cal. Evid. Code § 452(h).)

CBIA seeks judicial notice of the following five documents:

**Exhibit H**: An excerpt of OPR's 2003 General Plan Guidelines. Judicial notice of this document is appropriate under Evidence Code Section 452, subdivision (c) and (h) because it constitutes an official act of a public agency and is not reasonably subject to dispute.

**Exhibit I**: An excerpt of the environmental impact report for the 5th and Colorado Hotel Projects. Judicial notice of this document is appropriate under Evidence Code Section 452, subdivision (c) and (h) because it constitutes an official act of a public agency and is not reasonably subject to dispute.

**Exhibit J**: Yingling Fan, et al., *Is Sprawl Associated with a Widening Urban-Suburban Mortality Gap?*, Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 86, No. 5, p. 717, 2009. Judicial notice of the existence of the document is appropriate under Evidence Code Section 452, subdivision (h) because its existence is not reasonably subject to dispute. (*See People v. Pizarro* (1992) 10 Cal.App.4th 57, 72 n. 11.) CBIA argues that articles such as this could potentially be used by project opponents as substantial evidence of a fair argument that an impact related to urban environment.

**Exhibit K**: Yara Halasa, et al., *Quantifying the Impact of Mosquitoes on Quality of Life and Enjoyment of Yard and Porch Activities in New Jersey*, PLoS ONE, Volume 9, Issue 3, 2014. Judicial notice of the existence of this document is appropriate under Evidence Code Section 452, subdivision (h) because its existence is not reasonably subject to dispute. (*See People v. Pizarro* (1992) 10 Cal.App.4th 57, 72 n. 11.) CBIA argues that articles such as this could potentially be used by project opponents as substantial evidence of a fair argument that an impact related to vectors.

**Exhibit L**: A printout from the District's official website http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES.aspx. Judicial notice of this document is appropriate under Evidence Code Section 452, subdivision (c) and (h) because it constitutes an official act of a public agency and is not reasonably subject to dispute.

CBIA respectfully requests this Court grant judicial notice of Exhibits H through L.

Dated: May 28, 2014

Respectfully submitted,
Cox, Castle & Nicholson LLP

By: ______________________
Andrew B. Sabey
Attorneys for Plaintiff and Respondent California Building Industry Association

# EXHIBIT H

EXHIBIT H

STATE OF CALIFORNIA

# General Plan Guidelines

2003

GOVERNOR'S OFFICE OF PLANNING AND RESEARCH

**State of California**
Gray Davis, Governor

**Governor's Office of Planning and Research**
Tal Finney, Interim Director
1400 Tenth Street
Sacramento, CA 95814
916-322-2318

State Clearinghouse Director: Terry Roberts
Lead Editor: Brian Grattidge
Assistant Editor: Anya Lawler

October 2003



This document is available on the Internet at *http://www.opr.ca.gov.*

# Director's Message

The Governor's Office of Planning and Research (OPR) is proud to announce the publication of the *2003 General Plan Guidelines*. These advisory guidelines serve as a valuable reference for cities and counties in the preparation of local general plans. It is our hope that the *General Plan Guidelines* will be useful not only to city and county planning staffs, but to elected officials, planning consultants, and members of the public.

The State Legislature declared in 1976 that "decisions involving the future growth of the state, most of which are made and will continue to be made at the local level, should be guided by an effective planning process, including the local general plan, and should proceed within the framework of officially approved statewide goals and policies." In all of its work, OPR attempts to encourage more collaborative and comprehensive land use planning at the local, regional, and statewide levels to achieve sustainable development goals of protecting the environment, maintaining a healthy economy, and ensuring equitable treatment of all people.

In addition to the *General Plan Guidelines*, OPR has recently published the *Municipal Service Review Guidelines,* which provide guidance for Local Agency Formation Commissions (LAFCOs) to address the delivery of municipal services at a regional level, in a manner that informs other LAFCO boundary-setting decisions. The *Municipal Service Review Guidelines* will be followed by *A Guide to the LAFCO Process for Incorporations*, which will assist LAFCOs in establishing new city boundaries. Finally, for the first time in twenty-five years, the *Environmental Goals and Policy Report* will provide the statewide framework that guides the infrastructure investments and comprehensive plans of state agencies and departments.

As the *General Plan Guidelines* enters its thirtieth year, I know you will find the 2003 edition to be an invaluable tool in the practice of local planning.

Tal Finney
Interim Director

October 2003
Sacramento, California

jobs/housing balance alone could easily result in a city composed of single-use residential subdivisions on one side of town and single-use business parks and shopping centers on the other side of town. At the scale of the region, this might be preferable to a jobs/housing imbalance, but at the scale of the community and of the neighborhood it does not improve livability or reduce dependence on the automobile. While it is not likely that most employees of a local business will also live in the neighborhood, it is important that the planning of the neighborhood not preclude that possibility for those who would chose it.

## ENVIRONMENTAL JUSTICE

Environmental justice is defined in state planning law as 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 (§65040.12(e)). The Governor's Office of Planning and Research (OPR) is required to provide guidance to cities and counties for integrating environmental justice into their general plans (§65040.12(c)). This section discusses the framework for environmental justice and the relationship of environmental justice to the general plan. The recommendations in this chapter are also reflected in the chapters on the required general plan elements (Chapter 4), optional elements (Chapter 6), and public participation (Chapter 8).

### Federal Framework

The basis for environmental justice lies in the Equal Protection Clause of the U.S. Constitution. The Fourteenth Amendment expressly provides that the states may not "deny to any person within [their] jurisdiction the equal protection of the laws" (U.S. Constitution, amend. XIV, §1).

On February 11, 1994, President Clinton signed Executive Order (E.O.) 12898, titled "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." The executive order followed a 1992 report by the U.S. Environmental Protection Agency (U.S. EPA) indicating that "[r]acial minority and low-income populations experience higher than average exposures to selected air pollutants, hazardous waste facilities, and other forms of environmental pollution." Among other things, E.O. 12898 directed federal agencies to incorporate environmental justice into their missions.

In a memorandum accompanying E.O. 12898, President Clinton underscored existing federal laws that can be used to further environment justice. These laws include Title VI of the Civil Rights Act of 1964 and the National Environmental Policy Act (NEPA), among others. Title VI prohibits any recipient (state or local entity or public or private agency) of federal financial assistance from discriminating on the basis of race, color, or national origin in its programs or activities (42 USC §2000d-§2000d-7). State and local agencies that receive federal funding must comply with Title VI. Pursuant to the Civil Rights Restoration Act of 1987, this requirement applies to all agency programs and activities, not just those that receive direct federal funding. In response, many state and local agencies that receive federal funding have initiated environmental justice programs of their own.

NEPA applies to projects carried out or funded by a federal agency (including the issuance of federal permits). NEPA is useful relative to environmental justice because it requires public participation and discussion of alternatives and mitigation measures that could reduce disproportionate effects on low-income and minority populations. On December 10, 1997, the Council on Environmental Quality (CEQ) released *NEPA Guidance for Federal Agencies on Key Terms in E.O. 12898.* This document is a useful reference for planners, although it is focused on environmental review of individual projects rather than long-term comprehensive land use planning.

### State Framework

Anti-discrimination laws existed in California prior to the passage of the first state environmental justice legislation in 1999. The California Constitution prohibits discrimination in the operation of public employment, public education, or public contracting (Article I, §31). State law further prohibits discrimination under any program or activity that is funded or administered by the state (§11135). The Planning and Zoning Law prohibits any local entity from denying any individual or group of the enjoyment of residence, land ownership, tenancy, or any other land use in California due to the race, sex, color, religion, ethnicity, national origin, ancestry, lawful occupation, or age of the individual or group of individuals (§65008). The Fair Employment and Housing Act (FEHA) specifically prohibits housing discrimination on the basis of race, color, religion, sex, sexual orientation, marital status, national origin, ancestry, familial status, disability, or source of income (§12900, et seq.)

In 1999, Governor Davis signed SB 115 (Solis, Chapter 690, Statutes of 1999) into law, defining environmental justice in statute and establishing OPR as the coordinating agency for state environmental justice programs (§65040.12). SB 115 further required the California Environmental Protection Agency (Cal/EPA) to develop a model environmental justice mission statement for boards, departments, and offices within the agency by January 1, 2001 (Public Resources Code §72000-72001).

In 2000, Governor Davis signed SB 89 (Escutia, Chapter 728, Statutes of 2000), which complemented SB 115 by requiring the creation of an environmental justice working group and an advisory group to assist Cal/EPA in developing an intra-agency environmental justice strategy (Public Resources Code §72002-72003). SB 828 (Alarcón, Chapter 765, Statutes of 2001) added and modified due dates for the development of Cal/EPA's intra-agency environmental justice strategy and required each board, department, and office within Cal/EPA to identify and address any gaps in its existing programs, policies, and activities that may impede environmental justice no later than January 1, 2004 (Public Resources Code §71114-71115).

AB 1553 (Keeley, Chapter 762, Statutes of 2001) required OPR to incorporate environmental justice considerations in the *General Plan Guidelines*. AB 1553 specified that the guidelines should propose methods for local governments to address the following:

- Planning for the equitable distribution of new public facilities and services that increase and enhance community quality of life.
- Providing for the location of industrial facilities and uses that pose a significant hazard to human health and safety in a manner that seeks to avoid overconcentrating these uses in proximity to schools or residential dwellings.
- Providing for the location of new schools and residential dwellings in a manner that avoids proximity to industrial facilities and uses that pose a significant hazard to human health and safety.
- Promoting more livable communities by expanding opportunities for transit-oriented development.

### Forms of Inequity

Problems of environmental justice can be broken down into two categories: procedural inequity and geographic inequity. In other words, unfair treatment can manifest itself in terms of process or in terms of results.

Procedural inequity occurs when the planning process is not applied uniformly. Examples of procedural inequity include:

- "Stacking" commissions or committees with certain interests while ignoring the interests of other segments of the community, such as minority and low-income residents.
- Holding meetings at times or in locations that minimize the ability of certain groups or individuals to participate.
- Using English-only written or verbal communication when a non-English speaking population will be affected by a planning decision.
- Requiring lower levels of mitigation for projects affecting low-income or minority populations.
- Unevenly enforcing environmental rules.

Geographic inequity describes a situation in which the burdens of undesirable land uses are concentrated in certain neighborhoods while the benefits are received elsewhere. It also describes a situation in which public amenities are concentrated only in certain areas. Examples of geographic inequity include situations in which:

- Certain neighborhoods have a disproportionate share of industrial facilities that handle or produce hazardous waste, while the economic benefits are distributed to other neighborhoods (in the form of jobs and tax revenue).
- Certain neighborhoods have a disproportionate share of waste disposal facilities, while the benefits of such facilities are received by the community or region as a whole.
- Certain neighborhoods have ample community centers, parks, and open space and thus experience more of the environmental benefits associated with these amenities, while other neighborhoods have fewer such amenities.

### Public Participation

Community involvement in the planning process is an important part of environmental justice. Cities and counties should develop public participation strategies that allow for early and meaningful community involvement in the general plan process by all affected population groups. Participation plans should incorporate strategies to overcome linguistic, institutional, cultural, economic, and historic barriers to effective participation. Chapter 8 is dedicated to the issue of public participation and suggests methods to improve outreach to and communication with all population groups, including low-income and minority populations.

## Compatibility

At the general plan level, discussions about environmental justice involve a central land use concept: compatibility. The primary purpose of planning, and the source of government authority to engage in planning, is to protect the public health, safety, and welfare. Incompatible land uses may create health, safety, and welfare issues for the community. Geographic inequity occurs when incompatible land uses disproportionately affect a particular socioeconomic segment of the community. In this sense, environmental justice problems indicate a failure of land use planning to deliver on its original promise—reducing the harmful effects of incompatible land uses.

Traditionally, zoning has attempted to minimize health and safety risks by segregating land uses. However, taking this approach too far has negative consequences that run counter to the goals of sustainable development. Rigid separation of land uses has resulted in disconnected islands of activity and contributed to sprawl. As discussed above, development patterns characterized by single-use zoning result in the automobile being the only viable transportation option, which has high environmental, economic, and social costs.

The traditional pyramidal zoning model places single-family homes at the pinnacle, followed by denser multi-family housing, followed by office and commercial uses, and, finally, followed by industrial uses at the base. In this model, land uses at a lower level on the pyramid are not allowed within the higher designations (e.g., commercial uses are not allowed in multi-family zones, and apartments are not allowed in single-family zones). This is giving way to a much more sustainable model, where the middle of the pyramid consists of mixed-use development that integrates housing, commercial, and recreational/cultural activities. Despite the desirability of mixed-use zoning, it is important to recognize that there are certain industrial uses that will always be incompatible with residential and school uses.

Residential and school uses are harmed by incompatible land uses that have environmental effects, such as noise, air emissions (including dust), and exposure to hazardous materials. The compatibility problem also operates in reverse. Incompatible uses adjacent to residential units, schools, or environmentally sensitive areas may also suffer negative consequences in the form of higher mitigation costs or the curtailment of economic activities. Specific examples of land use incompatibility include:

- Residential and school uses in proximity to industrial facilities and other uses that, even with the best available technology, will contain or produce materials that, because of their quantity, concentration, or physical or chemical characteristics, pose a significant hazard to human health and safety.
- Residential and school uses adjacent to intensive agricultural uses.
- Residential and school uses adjacent to major thoroughfares, such as highways.
- Residential or commercial uses in proximity to resource utilization activities, such as mining or oil and gas wells.

Issues related to industrial overconcentration and the location of residential dwellings and schools are discussed below.

## Information and Analysis

Good information is critical to making informed decisions about environmental justice issues. The analysis of environmental justice problems has benefited from the advancement of geographic information systems (GIS), as has the entire planning field. The role of data in the general plan process is discussed more fully in Chapter 3. The data suggestions for the mandatory general plan elements (Chapter 4) include much of the information necessary for developing environmental justice policies.

Relevant information for addressing environmental justice issues includes, but is not limited to:

- Base map of the city or county planning area.
- General plan designations of land use (existing and proposed).
- Current demographic data.
  - Population location and density.
  - Distribution of population by income.
  - Distribution of population by ethnicity.
  - Distribution of population by age.
- Location of public facilities that enhance community quality of life, including open space.
- Location of industrial facilities and other uses that contain or produce materials that, because of their quantity, concentration, or physical or chemical characteristics, pose a significant hazard to human health and safety.
- Location of existing and proposed schools.
- Location of major thoroughfares, ports and airports.
- Location and density of existing and proposed residential development.

Although the use of population data is a normal part of the planning process, cities and counties do not always gather socioeconomic data when preparing or substantially revising their general plans. Jurisdictions do have to collect some socioeconomic data during the preparation of the housing element, such as income level and persons with special housing needs (elderly, farmworkers, single head of household, etc.), but this required information is not enough to paint a complete socioeconomic picture of the community. From an environmental justice perspective, socioeconomic data is useful for a number of things, including:

- Improving the public participation process.
- Identifying low-income and minority neighborhoods that are underserved by public facilities and services that enhance quality of life and planning for the equitable distribution of such facilities and services.
- Planning for infrastructure and housing needs.
- Identifying low-income and minority neighborhoods in which industrial facilities and uses that pose a significant hazard to human health and safety may be overconcentrated.

As discussed below, the definitions of both equitable distribution and overconcentration do not depend on socioeconomic factors. However, reversing historical problems of procedural and geographic inequity requires accurate socioeconomic information in order to develop policies and prioritize implementation measures.

### Relationship to the General Plan

Cities and counties may incorporate environmental justice into their general plans in several ways. A city or county may choose to adopt an optional environmental justice element. However, OPR recommends incorporating policies supportive of environmental justice in all of the mandatory elements of the general plan. These policies should also be reflected in any optional elements. In keeping with the internal consistency requirement, environmental justice policies in one element cannot conflict with the policies of another element. For example, if the land use element contains a policy prohibiting residential uses adjacent to certain industrial uses, properties affected by that policy could not be used as part of the housing element site inventory.

### Public Facilities and Services

Cities and counties should plan for the equitable distribution throughout the community of new public facilities and services that increase and enhance community quality of life, given the fiscal and legal constraints that restrict the siting of such facilities.

Public facilities and services that enhance quality of life include, but are not limited to, parks, open space, trails, greenbelts, recreational facilities (including senior and youth centers), community centers, child care centers, libraries, museums, cultural centers, science centers, and zoos. The equitable distribution of facilities and services has two components. The first component is the number and size of facilities. Simply put, a community should have adequate facilities and services to serve all residents equally. The second component is access, which can be measured as the distance or travel time from each residential area to the facility or service. Access may also be measured by the ability to use a variety of transportation modes, including public transit, walking, and bicycling, to travel between each residential area and the facility or service. A geographic analysis of residential areas and the location of public amenities may reveal underserved neighborhoods. Policies addressing the distribution of beneficial public facilities and services should address existing disparities as well as the needs of future residents.

Public facilities and services that enhance community quality of life can be divided into three basic types for purposes of distribution. The first type is neighborhood facilities, such as parks, that serve a specific neighborhood or subdivision. The second type is district facilities, such as branch libraries or recreational centers, that serve more than one neighborhood. The third type is unique facilities, where one facility serves the entire community—"community" being an incorporated city or, for counties, an unincorporated area.

Neighborhood facilities should be geographically dispersed throughout the community. Examples include parks, tot lots, and neighborhood activity centers. These facilities should be located within the neighborhood they serve. Public amenities can serve to anchor a neighborhood and should be centrally located. Furthermore, locating neighborhood-serving public facilities within walking distance of most residents will encourage use and provide a sense of place. A distance of a quarter to a half mile is generally considered a walkable distance.

Planning for the location of district facilities should follow the same principles as above. Since these facilities serve several neighborhoods, they should be centrally located relative to the neighborhoods they serve. Locating such facilities along transit corridors or in transit-oriented developments will increase their accessibility (see Transit-Oriented Development later in this chapter).

Examples of unique public facilities include the central library or city museum. Where a community has only one recreational or cultural center, that would be considered a unique facility or service. These facilities should be located in the civic center or urban core rather than isolated in remote single-use complexes. They should be close to transit to allow maximum access for the entire community.

Consideration should also be given to regional facilities, which may exhibit the characteristics of all three basic types described above. Regional facilities include trails, networks of open space such as greenbelts, regional parks and recreation areas, etc. Linear facilities (such as trails and greenbelts) may serve several neighborhoods but are also a unique amenity for the entire area. The same is true of large regional recreational areas. Individual cities and counties may have less control over the location of regional facilities, which may be operated by special districts or joint powers authorities. Cities and counties have even less control over state and federal parks, recreational areas, and forests, although cities and counties should account for such facilities in the planning process. New regional facilities are rare, and when the opportunity to acquire or develop such facilities arises, the location may be predetermined by such factors as natural features, abandoned rail lines (for trail use), or the availability of large undeveloped properties. Nevertheless, planners should consider existing and proposed regional facilities when analyzing community access to public facilities that contribute to quality of life and when planning for future such facilities.

Locating public facilities and uses according to these planning principles may be limited by fiscal and legal constraints. Fiscal constraints include the relative cost of land and the ability of public agencies to obtain financing for acquisition and construction. Legal constraints include, but are not limited to, local, state, and federal regulations for the protection of the environment, public health and safety, and the preservation of natural and cultural resources, including historical and archeological resources.

### Industrial Facilities

Cities and counties should develop policies that provide for the location of industrial facilities and other uses that, even with the best available technology, will contain or produce materials that, because of their quantity, concentration, or physical or chemical characteristics, pose a significant hazard to human health and safety in a manner that seeks to avoid overconcentrating these uses in proximity to schools or residential dwellings.

Overconcentration occurs when two or more industrial facilities or uses, which do not individually exceed acceptable regulatory standards for public health and safety, pose a significant hazard to adjacent residential and school uses due to their cumulative effects.

Facilities that emit, handle, store, or dispose of hazardous materials are regulated by a variety of agencies. These agencies include local Certified Unified Program Agencies (such as environmental health departments or fire departments), air districts, regional water quality control boards, the California Department of Health Services, the California Integrated Waste Management Board, and the California Department of Toxic Substance Control (DTSC). However, cities and counties, as the local land use authority, are primarily responsible for the location and distribution of potentially hazardous industrial facilities through their general plans and zoning ordinances.

Cities and counties may pursue several strategies within their general plans to address overconcentration. Strategies may include:

- Buffer zones between industrial and residential land uses.
- Policies addressing individual project siting decisions.
- Capping the number of certain facilities and uses.
- Changing land use designations in overconcentrated areas.

Buffer zones are a broad approach to land use compatibility. Buffer zone policies may be approached in one of two ways. First, the general plan land use diagram may designate transitional land uses between industrial and residential areas. Transitional uses may include open space, light industry, office uses, business parks, or heavy commercial uses. The land use policies for these buffer areas should prohibit school uses (see discussion below on school siting). Appropriate distances for buffer areas will vary depending on local circumstances. Factors such as the intensity of nearby residential uses, prevailing

#### Analyzing Equitable Distribution

A University of Southern California study, *Parks and Park Funding in Los Angeles: An Equity Mapping Analysis*, is an example of how equitable distribution of public amenities (in this case, parks and open space) can be analyzed using a geographic information system (GIS). The report is available at www.usc.edu/dept/geography/espe.

winds, geographic features, and the types of facilities and uses allowed in industrial areas should be considered.

Second, buffer zones may be implemented at the project level. One weakness of general buffer zone policies is the difficulty of making *a priori* decisions about how much distance is needed to minimize potential health and safety hazards to residential and school uses. A stronger approach may be buffer policies aimed at individual siting decisions.

Approval of certain industrial facilities or uses can be made conditional if they are within a certain distance of residential or school uses and/or contain or produce hazardous materials. This allows the city or county to consider the potential hazards associated with individual facilities or uses on a case-by-case basis. General plan policies can outline consistent standards to be used in approving, conditionally approving, or denying proposed locations for industrial facilities and other uses that may pose a significant hazard to human health and safety. Such standards should be reflected in the zoning ordinance that implements the general plan (see Chapter 10 for a discussion of zoning consistency).

Approval of a conditional use is discretionary and thus would be subject to the California Environmental Quality Act (CEQA). CEQA requires decision makers to consider the environmental consequences of their actions. CEQA also serves as an important consultation tool. A lead agency must consult with an affected school district if any facility that would create hazardous air emissions or handle acutely hazardous material is proposed within a quarter mile of a school (Public Resources Code §21151.4).

Another policy response to overconcentration is to cap the number of potentially hazardous facilities within a certain distance of each other. For example, the State of Georgia does not allow siting of a new solid waste facility if two such facilities already exist within a two mile radius of the proposed facility. While capping policies are easy to implement and understandable to the public, they have serious drawbacks. Numerical caps are more likely to be based on perception and political compromise than scientific merit. Without analyzing the type, quantity, and concentration of materials to be contained or produced at a proposed facility, it is difficult to determine the number of facilities that would create a situation of overconcentration.

The general plan strategies above can assist a city or county in addressing future problems of overconcentration. General plans, which are by their nature concerned with future development, are not as effective at correcting past problems. One way to address existing or potential future problems of overconcentration is to change the land use designation for existing industrial areas. This approach differs from buffer zones in that buffer zones affect the land use designation of areas adjacent to existing or proposed industrial areas. Changing the allowable land uses in existing industrial areas prevents new industrial land uses from being established and may affect the expansion of existing facilities and uses (depending on how local policies treat pre-existing or "legal non-conforming," land uses).

An important caveat is to consider what new uses will be allowed in the previously industrial areas. A new environmental justice problem could be created if residences and schools are allowed without considering any lingering effects of industrial overconcentration. At the same time, where overconcentration is no longer an issue and effective remediation or clean-up is possible, so-called "brownfield" development is an important tool for a community's continued sustainable development.

Finally, planners should remember to differentiate between overconcentration and the mere presence of materials that may be classified as hazardous. Many neighborhood businesses, such as gas stations, photography studios, retail paint stores, dry cleaners, etc., may have hazardous materials present. While these activities must be conducted in a responsible manner in accordance with all environmental regulations, they should not be confused with those truly industrial activities that are inappropriate for residential or mixed-use areas.

### New Residential Uses and Schools

Cities and counties should provide for the location of new schools and residential dwellings in a manner that seeks to avoid locating these uses in proximity to industrial facilities and uses that will contain or produce materials that, because of their quantity, concentration, or physical or chemical characteristics, pose a significant hazard to human health and safety.

The location of new residential and school development is the flip side of the problem discussed in the section above. Given the need for new housing and schools and given the need to make efficient use of land, how do cities and counties deal with existing overconcentration of industrial uses? When designating areas for residential development, the city or county should identify any areas of overconcentration. Appropriate buffers should be placed between overconcentrated industrial areas and new residential areas. Using their authority over the approval and design of subdivisions, cities and counties may develop policies and standards related to industrial overconcentration and new residential subdivision approvals. These policies could include buffer zones, as well as the criteria to be used for rejecting new residential development (such as standards for risk to human health and safety from nearby industrial facilities and uses).

The location of new schools is of particular concern to both local governments and school districts. The general plan should identify possible locations for new schools. Such locations may be approximate and need not indicate specific parcels. Identifying appropriate school locations as part of the general plan process may avoid project-level problems of proximity to certain industrial facilities and uses. Due to the fragmentation of authority in the areas of land use planning and school siting and construction, it is recommended that the planning agency work closely with the school district to identify suitable school locations. Prior to adopting or amending a general plan, the planning agency must refer the proposed action to any school district within the area covered by the proposed action (§65352). The city or county should use this opportunity to engage school districts on issues of school siting.

For their part, school districts are required to notify the planning commission of the city or county prior to acquiring property for new schools or expansion of an existing school. School districts are not bound by local zoning ordinances unless the ordinance provides for the location of schools and the city or county has adopted a general plan (§53091). School districts can override the general plan and zoning ordinances with regard to the use of property for classroom facilities by a two-thirds vote of the school board (§53094). The school board cannot exercise this power for non-classroom facilities, such as administrative buildings, bus storage and maintenance yards, and warehouses. If the school board exercises their override power, they must notify the city or county within 10 days (§53904).

CEQA requires that the environmental document prepared for a new school identify whether the proposed site is any of the following: a current or former hazardous waste or solid waste disposal facility, a hazardous substances release site identified by DTSC, the site of one or more pipelines that carry hazardous substances, or located within a quarter mile of a facility that emits hazardous air emissions or handles acutely hazardous material (Public Resources Code §21151.8). If such facilities exist, the school board must make findings that the facilities would not endanger the health of those attending or employed by the proposed school or that existing corrective measures would result in the mitigation of any health endangerment.

## TRANSIT-ORIENTED DEVELOPMENT

Cities and counties should promote more livable communities by expanding opportunities for transit-oriented development (TOD) so that residents minimize traffic and pollution impacts from traveling for purposes of work, shopping, school, and recreation.

TOD is defined as moderate- to high-density development located within an easy walk of a major transit stop, generally with a mix of residential, employment, and shopping opportunities. TOD encourages walking and transit use without excluding the automobile. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use (*Statewide Transit-Oriented Development Study: Factors for Success in California*, California Department of Transportation, 2002).

A well-designed, vibrant TOD community can provide many benefits for local residents and businesses, as well as for the surrounding region. Compact development near transit stops can increase transit ridership and decrease rates of vehicle miles traveled (VMT), thereby yielding a good return on transit system investments. TOD can also provide mobility choices, increase public safety, increase disposable household income by reducing transportation costs, reduce air pollution and energy consumption rates, help conserve resources and open space, assist in economic development, and contribute to the housing supply.

TOD is a strategy that may help a community achieve its general plan goals related to circulation, housing, environmental quality, and economic development. Additionally, by improving access to jobs and housing and revitalizing existing neighborhoods, TOD can be a tool for promoting environmental justice.

A variety of factors need to be considered during the development and implementation of TOD. These factors include transit system design; community partnerships; understanding of local real estate markets; coordination among local, regional, and state organizations; and providing the right mix of planning and financial incentives and resources. A successful TOD will reinforce the community and the transit system. Transit operators, property owners, and residents should be involved in the development of TOD proposals.

Data to identify and assess potential locations for TOD should be collected during preparation of the land use, circulation, and housing elements of the general plan. An inventory of potential development (and redevelopment) sites within a quarter to a half mile of existing and proposed transit stops may reveal potential locations for TOD. Additional data may be used to verify the optimum location and mix of uses to further refine

# EXHIBIT I

EXHIBIT I

City of

**Santa Monica**

# 5th and Colorado Hotel Projects

# Final
# Environmental Impact Report

# SCH# 2012041084

## May 2013

*Prepared for:*

City of Santa Monica
Planning and Community Development Department
1685 Main Street
Santa Monica, CA 90401

*Prepared by:*

AMEC Environment & Infrastructure, Inc.
104 West Anapamu Street, Suite 204A
Santa Barbara, CA 93101

## 3.11 SOLAR ACCESS AND SHADOWS

This section analyzes the potential environmental effects of shadows created as a result of implementing the proposed projects. For purposes of this analysis, shading refers to placing land uses in shade, thereby preventing direct access to sunlight due to shadows cast by buildings or structures. The consequences of shadows on land uses may be positive, including cooling effects during warm weather, or negative, such as shading of exterior patios, the loss of natural light access, solar access energy generation purposes or the loss of warming influences during cool weather. Shadow effects are dependent upon several factors, including the local topography, the height and bulk of a project's structural elements, the shade sensitivity of adjacent land uses, the season and consequent length of shadows, and the duration of shadow projection.

### 3.11.1 Environmental Setting

Shade and Shadow Patterns

Shadow length and bearing (the direction in which they are cast) is dependent on the location (latitude and longitude) of the project site, which dictates the angle of the sun relative to the project site. Shadows are cast in a clockwise direction from west/northwest to east/northeast from approximately 7:00 AM to 4:00 PM or later depending on the time of the year: Summer Solstice (June 20), Spring/Fall Equinoxes (March 20 and September 22), and Winter Solstice (December 21). Generally, the shortest shadows are cast during the Summer Solstice and grow increasingly longer until the Winter Solstice. During the winter and peaking at Winter Solstice, the sun is lower in the sky and shadows are at their maximum coverage lengths.

*The lower profile of the existing structures within the project sites and proximity of adjacent structures limits the extent of shade and shadow currently cast on adjacent areas.*

Existing development on the project sites casts limited shade and shadow patterns on adjacent structures and uses. The one- to two-story height and lack of setbacks of the Midas building on the proposed Courtyard by Marriott site result in limited shadows cast primarily onto adjacent roadways, sidewalks, or alleys, as well as lower levels of adjacent buildings. The Midas building has a substantially lower profile than the adjacent five-story residential building (Step Up on

Fifth) that shares the property line to the north, so it does not cast substantial shadows onto Step Up on Fifth or onto the Silvercrest Senior Housing beyond. The proximity of the Midas Building, Step Up on Fifth, and the Silvercrest Senior Housing to the sidewalks on the south side of 5th Street (e.g., limited to non-existent building setbacks) results in substantial shading of sidewalks along much of the south side of 5th Street in the vicinity of the Courtyard by Marriott site. Shading of 4th Court Alley and the adjacent residential structure to the southeast of the Midas Building is limited to lower levels of the residential structure.

The existing three-story office building on the proposed Hampton Inn & Suites site is set back from all property lines, limiting shadows that extend beyond the site boundary. Limited shading also occurs from the two-story partial subterranean parking structure located on the north side of the existing office building. Shadows primarily extend to surface parking areas to the north and onto adjacent roadways or sidewalks. Shading of 5th Court Alley and the adjacent residential structure is limited due to the distance between the structures and relative height and mass of the existing office building. In addition to the structures, the Indian laurel fig trees that line 5th Street adjacent to the project sites provide shade to sidewalks and adjacent roadway.

Shadow-Sensitive Uses

Shadow-sensitive uses are those where sunlight is important to function, physical comfort, and/or commerce. Facilities and operations sensitive to the effects of shading include, but are not necessarily limited to, residential, recreational, institutional (e.g., schools, nursing homes, etc.), and some public outdoor spaces such as parks, restaurants with outdoor seating areas, plant nurseries, and existing solar collectors.[1]

*Shadow-sensitive uses in the vicinity of the project sites include several residential and mixed-use buildings, and a senior housing facility. Solar access for green buildings dependent on natural lighting, passive heating and solar panels, would be particularly sensitive to shade effects.*

The proposed project sites are near several shadow-sensitive uses, including the Silvercrest Senior Housing building; adjacent mixed use and/or residential structures (i.e., Step up on Fifth, the Luxe@1548, Colorado Court, Luxe@1539); and the outdoor patio area of an indoor/outdoor eatery (Umami Burger) (Figure 3.11-1; Table 3.11-1). In addition, the future Expo LRT Colorado/4th Street Station plaza is considered a future shadow-sensitive use.

[1] Shadow-sensitive uses for this analysis are defined based on the City of Santa Monica's Land Use and Circulation Element Final Environmental Impact Report, June 2010, which is consistent with the ***City of Los Angeles CEQA Thresholds Guide*** criteria.


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Shade-Sensitive Uses in the Vicinity of the Project Sites

FIGURE 3.11-1

**Table 3.11-1. Shadow-Sensitive Uses Potentially Affected by Project Shade and Shadow**

| Figure # | Address and/or Use | Type of Use | Relation to Project Site | # Stories | Shadow-Sensitive? |
|---|---|---|---|---|---|
| 1 | 1528 / 1548 6th Street | Luxe @ 1548 (~~Mixed Use~~Residential) | North and northeast | 6 | Yes |
| 2 | 502 Colorado Avenue | Colorado Court (Residential) | Southeast | 5 | Yes |
| 3 | 1548 5th Street | Step Up on Fifth (Residential) | North | 5 | Yes |
| 4 | 1530 5th Street | Silvercrest Residence | North | 6 | Yes |
| 5 | 500 Broadway Street | Outdoor Dining Patio (Indoor/Outdoor Restaurant - Umami Burger) | Northwest | 1 | Yes |
| 6 | 417 Colorado Avenue | Vacant (Pending Expo LRT Station) | Southeast and south | - | Yes |
| 7 | 1537-1539 4th Street | Luxe @ 1539 (~~Mixed Use~~Residential) | Southwest and west | 4 | Yes |

### 3.11.2 Regulatory Framework

City of Santa Monica Land Use and Circulation Element (LUCE)

The LUCE contains several policies that contain direction for the minimization of shadow impacts on solar access for adjacent parcels. Pertinent policies are listed below.

> **Policy LU16.1 Design Buildings with Consideration of Solar Pattern.** In designing new buildings, consider the pattern of the sun and the potential impact of building mass on habitable outdoor spaces and adjacent structures in order to minimize shadows on public spaces at times of the day and year when warmth is desired, and provide shade at times when cooling is appropriate, and minimize solar disruption on adjacent properties.
>
> **Policy LU16.2 Preserve Solar Access to Neighborhoods.** The same development standard that is adopted to require a step down building envelope to transition commercial buildings to lower adjacent residential properties also needs to assure solar access to the residential buildings.

**Goal H7:** Promote the creation of new housing that is tailored to the needs of residents and emphasizes amenities that increase the livability of the residential environment, such as ground floor open space and access to natural light and air.

> **Policy H7.5.** Ensure that site and building design responds to Santa Monica's natural environment through access to natural light and air.

**Goal B10:** Create an enhanced mixed-use, pedestrian boulevard [along Colorado Avenue] that provides residents, employees and visitors with an inviting landscaped pedestrian environment.

> **Policy B10.5.** Ensure that new commercial or mixed-use buildings adjacent to residential districts are contained within a prescribed building envelope that steps down toward the residential district to maintain access to light.

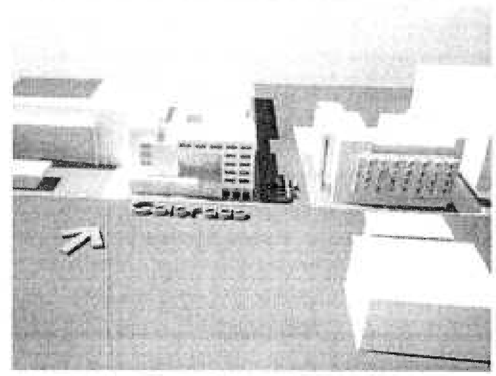
Thresholds of Significance

The City of Los Angeles has published guidelines for determining thresholds of significance related to shadows and shading. These criteria are utilized by the City of Santa Monica and further define how the City of Santa Monica interprets the CEQA Appendix G. The ***Los Angeles CEQA Thresholds Guide*** specifies:

> ***"A project impact would normally be considered significant if shadow-sensitive uses would be shaded by project-related structures for more than three hours between the hours of 9:00 AM and 3:00 PM Pacific Standard Time (between late***

*October and early April), or for more than four hours between the hours of 9:00 AM and 5:00 PM Pacific Daylight Time (between early April and late October)."*

### 3.11.3 Impact Assessment and Methodology



*The models utlized in this analysis map the potential shade 'footprint' based on the height and bulk of the proposed structures.*

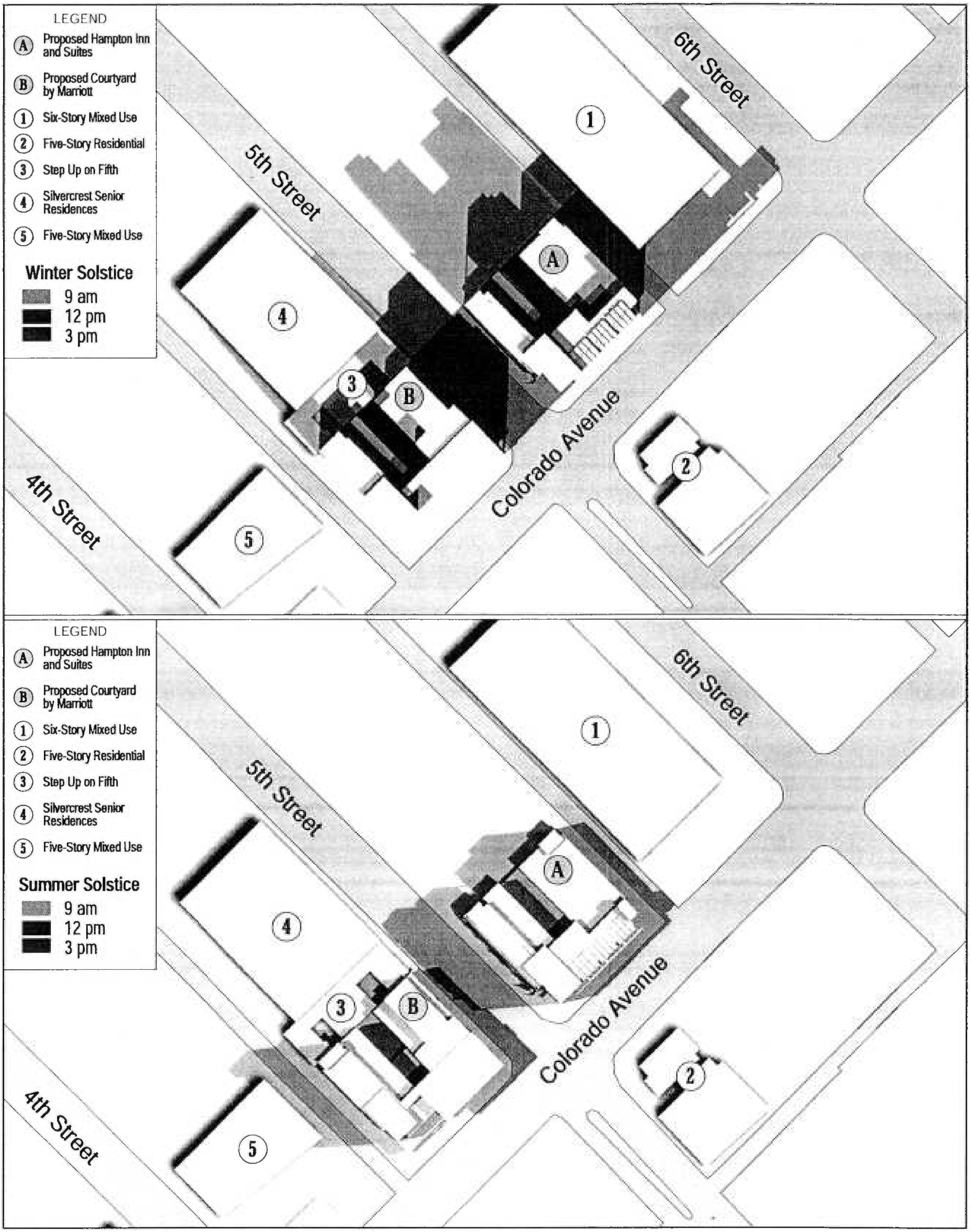
Shadow length and bearing (the direction in which they are cast) are dependent on the location (latitude and longitude) of the project site, which dictates the angle of the sun relative to the project site. In the Los Angeles area, the maximum shadow a building can cast is usually equivalent to three times its height during the Winter Solstice (City of Los Angeles 2006). The potential for off-site impacts is dependent on the length of shadows created by the project, and distance between the project site and the nearest shade-sensitive land uses. When there is potential for shade-sensitive uses to be placed in shadow by a proposed project for three or more hours, shading may create a potentially significant impact by substantially interfering with and adversely affecting the activities on that off-site property.

Methodology

Shadow simulations were prepared for the proposed hotels by using a computer generated model to identify the height and bulk of proposed buildings, mapping the "footprint" (location, shape, and size) of the project sites, and then calculating and diagramming the shadows that would be cast by the building components during the most extreme, or conservative, conditions. The model considers all buildings that could be impacted by shadows and includes simulations to illustrate potential shadow impacts. The analysis includes simulations for winter equinox, summer equinox, vernal equinox, and autumnal equinox at 9:00 AM, 12:00 PM, and 3:00 PM.

Projects Shade and Shadow

The proposed Hampton Inn & Suites and Courtyard by Marriott would each be six-story buildings of up to 84 feet in height or approximately 80 feet from finished first floor to the top of the main roof. This height would cast shadows on adjacent and vicinity buildings and public streets, including shadow-sensitive structures. Shadows created by the projects are modeled for both Summer and Winter Solstices, which are the longest and shortest days of the year, respectively (Figure 3.11-2), as well as the Vernal (spring) and Autumnal (fall) Equinoxes, of which the days and nights are of equal duration (Figure 3.11-3).

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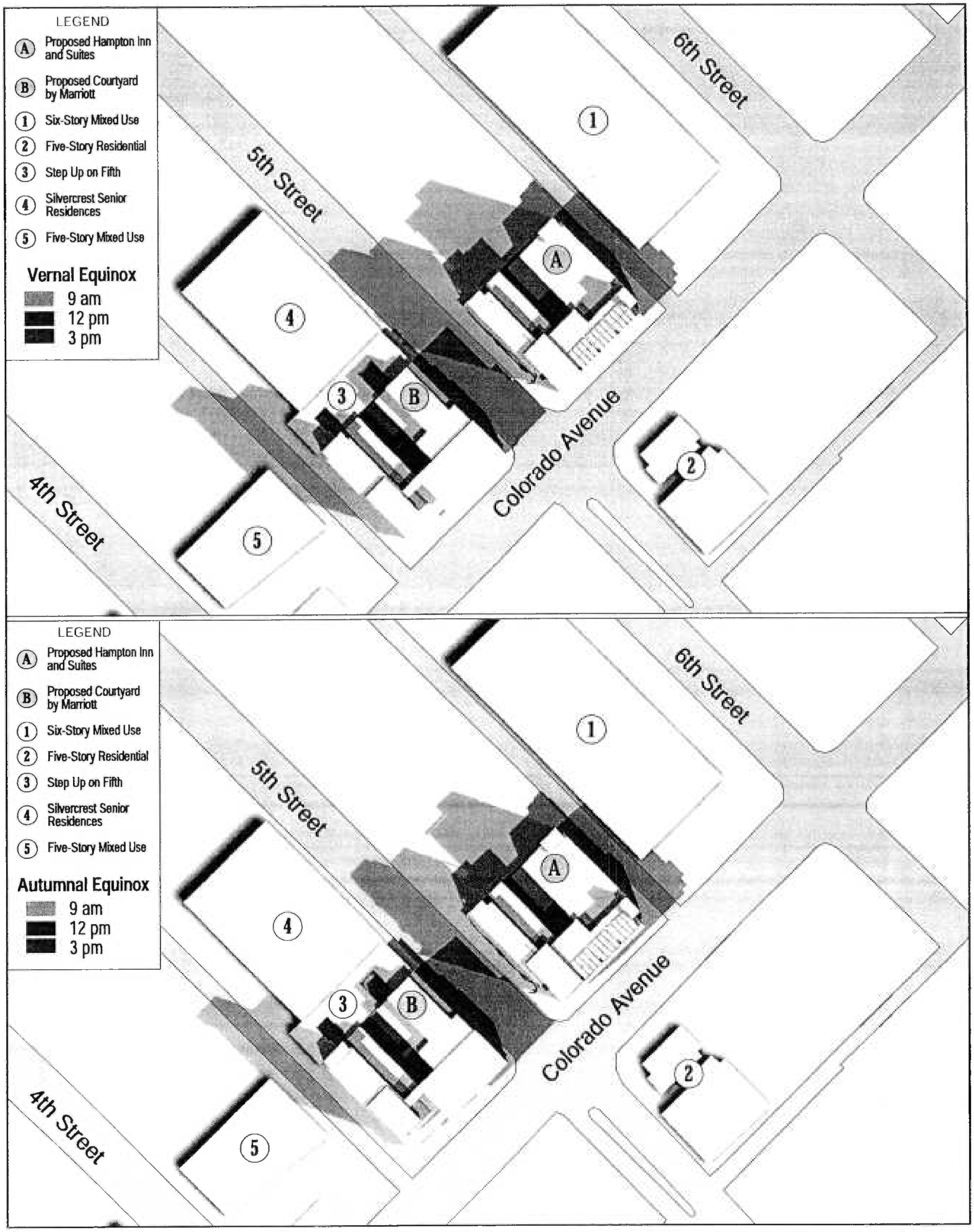
Shade and Shadow Effects of Project Structures: Winter and Summer Solstice

**FIGURE 3.11-2**




Shade and Shadow Effects of Project Structures:
Vernal and Autumnal Equinoxes

**FIGURE 3.11-3**

## 3.11.4 Project Impacts and Mitigation Measures

| | |
|---|---|
| *Threshold:* | *Would shadow-sensitive uses be shaded by project-related structures for more than three hours between the hours of 9:00 AM and 3:00 PM Pacific Standard Time (between late October and early April), or for more than four hours between the hours of 9:00 AM and 5:00 PM Pacific Daylight Time (between early April and late October)?* |

Impact Description

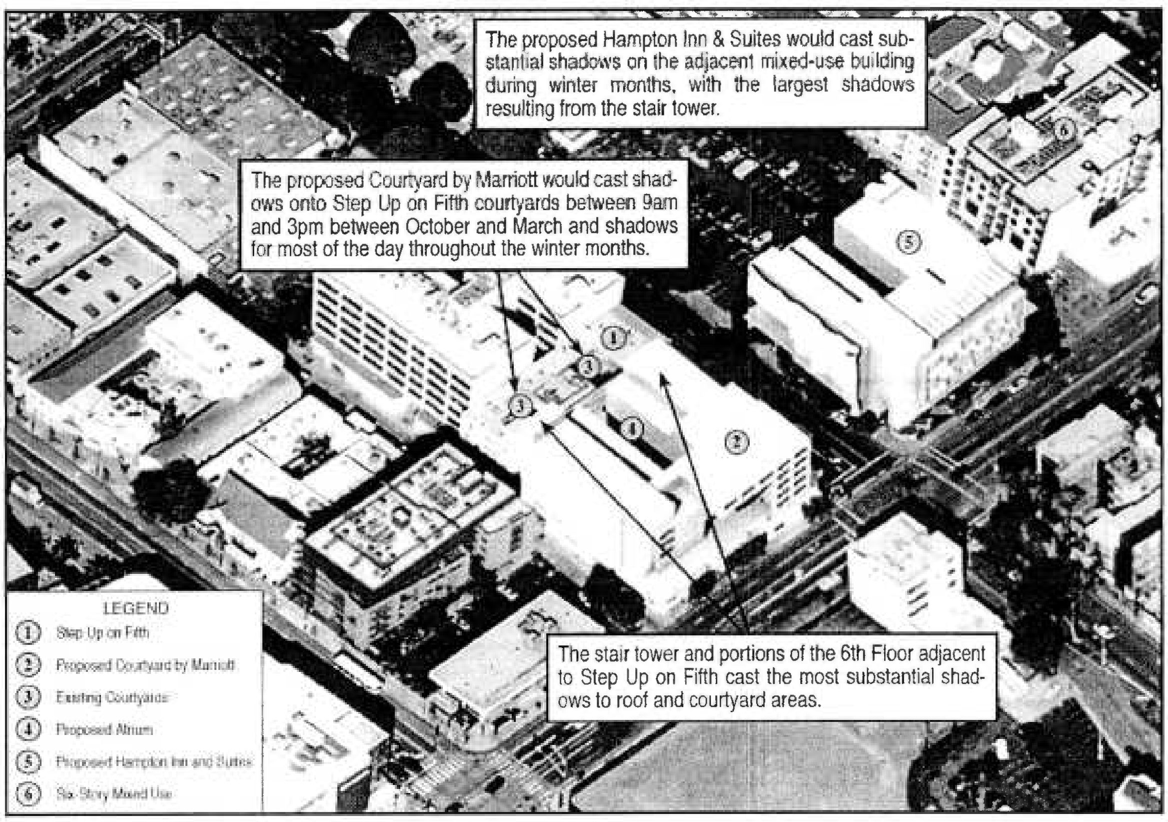
**SHD-1 The proposed project structures would obstruct solar access and cast shadows on adjacent structures for more than three hours in winter and four hours in summer.**

*Solar access to an east-facing opaque/ transparent façade (left side of building) and portions of the roof of the Step-Up on Fifth would be largely blocked by the proposed Courtyard by Marriott structure, significantly increasing shade to residences and common areas, and potentially reducing the building's operating efficiency.*

The proposed six-story Courtyard by Marriott and Hampton Inn & Suites buildings would replace the existing two-story Midas Building and three-story office building, casting substantially longer shadows than existing structures. These shadows would result in substantially increased shading of 5th Street and associated sidewalks, as well as to portions of 5th Court and 4th Court; however, these areas are not considered shade sensitive. Shadow-sensitive land uses adjacent to the project sites include residential and mixed-use buildings, an outdoor dining patio of the Umami Burger restaurant, and the future plaza of the Colorado/4th Street Station for the Expo LRT. Project development of each site, as well as in combination, would shade adjacent sensitive structures for greater than three hours in the winter and four hours in the summer, resulting in a potentially significant impact. Significant shadows from the proposed Courtyard by Marriott would occur on the Step Up on Fifth building throughout the year, while significant shadows from the Hampton Inn & Suites on the adjacent Luxe@1548 residential building to the northeast would occur for approximately 104 days during the winter. Project shadows are provided in Figures 3.11-2 and 3.11-3 and further described below.

### *Courtyard by Marriott Project Site*

Shadow studies performed for the proposed Courtyard by Marriott show significant shading of the Step Up on Fifth structure would occur throughout the year. No other adjacent structures would be shaded for greater than three hours in winter or four hours in summer. Shadows cast on the shadow-sensitive Step Up on Fifth residential building would shade southeast facing portions and building courtyards daily throughout the year. Shading from the proposed Courtyard by Marriott primarily results from stairwell and the northeast portions of the sixth floor, adjacent to Step Up on Fifth (Figure 3.11-4). Resident rooms are located on every other floor of Step Up on Fifth overlooking the private courtyards, which serve as the primary social areas for residents. Solar access to these areas would be substantially reduced by the proposed projects, shading internal common areas utilized by residents for greater than three hours in winter and four hours in summer, resulting in a potentially significant impact.

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5th and Colorado Shadow Impacts

FIGURE 3.11-4

The Step Up on Fifth building, constructed in 2009, was planned and designed to employ passive design strategies to increase energy efficiency. Passive strategies, including the aluminum shading façade and internal courtyard areas, make the Step Up on Fifth building highly energy efficient and reliant on solar access. The proposed structure would abut the property line adjacent to the Step Up on Fifth courtyards, resulting in the shading of these courtyards during morning and afternoon periods throughout the year (refer to Figure 3.11-3). In particular, the southwest courtyard would be substantially shaded by the proposed stairwell of the Courtyard by Marriott. This reduction in solar access would also potentially reduce the building's operating efficiency. This would be potentially inconsistent with LUCE Policy 16.1, which requires new development to minimize solar disruption on adjacent properties. In addition, LUCE Policy LU16.2 requires a step down building envelope to transition commercial buildings to lower adjacent residential properties to assure solar access to the residential buildings. While the internal atrium of the proposed Courtyard by Marriott would allow some ambient light through and reduce the effects of shading, substantial blockage of solar access would occur, resulting in a potentially significant impact.

### *Hampton Inn & Suites Project Site*

The proposed Hampton Inn & Suites would result in significant shading of the residences at the Luxe@1548 building to the northeast of the project site. This building contains residences and associated balconies that face the proposed hotel, which would be shaded for greater than three hours during winter, extending from approximately February 4 and October 24.[2] Additionally, morning shadows would extend across the existing parking lot towards the Umami Burger; however, shadows would occur for less than three hours and would not occur during normal business hours. The proposed Hampton Inn & Suites would result in three or more hours of shading to residences and associated balconies at Luxe@1548 located to the northeast of the project site, resulting in a potentially significant impact.

*A mixed-use residential complex located across 5th Court to the north of the Hampton Inn & Suites site is anticipated to experience significant periods of shade from the proposed hotel, particularly during winter months.*

[2] As depicted in the Winter Solstice model in Figure 3.11-2, the 12PM as well as the 3PM shadows cross the mixed use building to the north, indicating shade over a period of 3 or more hours. Dates provided are based on additional modeling that was performed to identify the period that shading between 12PM and 3PM would occur.

The proposed Courtyard by Marriott and the Hampton Inn & Suites would each result in shading of adjacent sensitive uses in exceedance of City of Santa Monica thresholds, resulting in a significant and unavoidable impact.

Mitigation Measures

*SHDW-1a* *In order to protect solar access, the Planning Commission and City Council shall review the design (i.e., stepbacks, height, structural elements, site coverage) of the proposed projects. For the proposed Courtyard by Marriott and Hampton Inn & Suites, redesign measures such as additional step back of the fifth and sixth level and relocation the proposed stairwell closet to the Step Up on Fifth Building would be required to eliminate the shadow impact. For the Hampton Inn and Suites, relocation of both stairwells would be required or elimination of the sixth story.*

Residual Impacts

The proposed projects' shadow impacts could be mitigated through inclusion of step backs on the fifth and sixth stories on the side of the structures closest to impacted uses, as well as relocation of stairwells. For the Courtyard by Marriot this would require step backs of at least nine feet for the fifth and sixth stories adjacent to the Step Up on Fifth building. In addition, the stairwell for the Courtyard by Marriott building closest to Step Up on Fifth would need to be relocated at least 50 feet to the southeast in order to eliminate the shade and shadow impact on that building. For the Hampton Inn & Suites, in order to eliminate the shade and shadows impact on the Luxe@1548 building, step backs of at least nine feet would be required on the fifth and sixth floors along the northwest portion of the building as well as relocation of both stairwells at least 20 feet further south from the Luxe@1548 building. Alternately, elimination of the sixth floor of the Hampton Inn and Suites would reduce this impact to less than significant.

While such modifications would eliminate shadow impacts, they would potentially result in building code conformity issues (i.e., appropriate distances from fire stairwells), major design complications due to relocation of the stairwells that would require significant changes to the overall building design, and substantial losses in useable floor space. Because these proposed mitigation measures would require major changes in project design, the feasibility and extent of fully implementing these measures would need to be determined during the Planning Commission and City Council review of the proposed hotels. However, it should be noted that use of step backs alone would substantially reduce both the frequency and duration of shading impacts, without requiring major redesign. If the Planning Commission and City Council determine that building redesign is required, such redesign would be subject to and based upon future modeling to ensure that redesign results in the elimination of shadow impacts. Because full mitigation of these impacts would require such major design changes that are more akin to a project alternative, shadow impacts would remain significant and unavoidable.

Cumulative Impacts

Cumulative development of buildings of greater height, including the proposed project, would generally increase shadowing throughout the City. Table 3-0 in Section 3.0, Cumulative Setting, provides a list of known development projects located throughout the City. Based on a review of this list, some projects in the immediate project vicinity could result in cumulative shadow effects in combination with the proposed projects. The shadow effects of individual buildings would be addressed on a case-by-case basis since shadowing is dependent upon building height, massing, and location, as well as the immediately surrounding uses. Nonetheless, the proposed projects would result in a cumulatively significant impact to shade and shadow conditions.

# EXHIBIT J

EXHIBIT J

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# Is Sprawl Associated with a Widening Urban–Suburban Mortality Gap?

Yingling Fan and Yan Song

**ABSTRACT** *This paper examines whether sprawl, featured by low development density, segregated land uses, lack of significant centers, and poor street connectivity, contributes to a widening mortality gap between urban and suburban residents. We employ two mortality datasets, including a national cross-sectional dataset examining the impact of metropolitan-level sprawl on urban–suburban mortality gaps and a longitudinal dataset from Portland examining changes in urban–suburban mortality gaps over time. The national and Portland studies provide the only evidence to date that (1) across metropolitan areas, the size of urban–suburban mortality gaps varies by the extent of sprawl: in sprawling metropolitan areas, urban residents have significant excess mortality risks than suburban residents, while in compact metropolitan areas, urbanicity-related excess mortality becomes insignificant; (2) the Portland metropolitan area not only experienced net decreases in mortality rates but also a narrowing urban–suburban mortality gap since its adoption of smart growth regime in the past decade; and (3) the existence of excess mortality among urban residents in US sprawling metropolitan areas, as well as the net mortality decreases and narrowing urban–suburban mortality gap in the Portland metropolitan area, is not attributable to sociodemographic variations. These findings suggest that health threats imposed by sprawl affect urban residents disproportionately compared to suburban residents and that efforts curbing sprawl may mitigate urban–suburban health disparities.*

**KEYWORDS** *Mortality, Sprawl, Smart growth, Urban health penalty, Health disparities*

## INTRODUCTION

Whether health disparities exist between urban and suburban residents has been debated in the field of public health for centuries. Early cities in the nineteenth or the early twentieth century were developed with rapid population growth in an environment without proper sanitation. High population density coupled with accumulation of city waste was likely to deteriorate air quality, contaminate water supply, provide new foci of infection, and create favorable conditions for the rapid transmission of disease from host to host—all of which led to elevated mortality risks among urban residents.[1–3] Modern city life, although offering health benefits through improved access to medical care, sanitation, education, jobs, social support, and higher income,[4] still threatens health via greater exposure to environmental pollutions, social stress, infections, violence, and accidents.[5]

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W. H. McNeil explicitly developed a conceptual model to explain variations in mortality rates between large metropolitan centers and their more thinly settled hinterlands.[6] Central areas, he argued, act as endemic reservoirs of diseases which spill over to their hinterlands in the form of recurrent epidemics. Urban populations thus experience generally higher and more stable levels of mortality. Hinterland mortality, by contrast, is less severe but is subject to violent short-term fluctuations.[6] Empirical studies conducted in the 1970s and 1980s concur with McNeil's model of the urban health penalty. Many suggest that there is a general increased risk of death for urban residents when compared to suburban residents.[7–10] However, studies in the 1970s and 1980s inadequately controlled for confounding variables such as race, ethnicity, and socioeconomic status. To some extent, "white flight"—the demographic shift in the first half of the twentieth century where middle-class families moved away from inner-city neighborhoods and where inner-city residents became equated with disadvantaged groups such as minority and low-income households—might explain the higher mortality rates found in urban areas in the 1970s and 1980s.[4]

More recent and rigorous studies on urban–suburban health disparities offer mixed and inconsistent findings. House et al. studied a national sample of 3,617 adults and found that significant urban mortality risk exists among white men, but not among white women.[5] Surprisingly, African Americans in suburban areas were found to have mortality risks as high as those in urban areas. Geronimus et al. selected several pairs of African-American communities and non-Hispanic white communities and investigated urban–rural disparities in mortality rates.[11] Their results contradict the findings of House et al., suggesting that African-American residents of urban communities suffer extremely high and growing rate of excess mortality. However, the contradiction may be due to the specific focus of Geronimus et al. on urban–rural disparities, which is different from the focus of House et al. on urban–suburban disparities. Smith et al. and Hayward et al. focused on a population of men 55 years or older and found that excess mortality existed among urban residents even after controlling for differences in social class and lifestyle factors between urban and suburban residents.[12,13]

Although the aforementioned studies performed adjustments for population composition and socioeconomic status, no study has yet examined how the extent of urban–suburban health disparities in a metropolitan area may be influenced by the region's built environment. The built environment, encompassing all of the buildings, spaces, and products that are created or significantly modified by people, not only forms a backcloth against which people live, work, and play,[14] but also to some degree determines residents' exposure to environmental risks and the associated physiological and psychosocial impacts.[15] Thus, the built environment has a profound impact on the health of its inhabitants, and different types of metropolitan environments (e.g., compact versus sprawling) each offer unique urban and suburban experiences, leading to a varied degree of urban–suburban health disparities.

Figure 1 illustrates a conceptual framework linking the built environment to health outcomes. The mediating factors and downstream pathways illustrated in Figure 1 are of particular interest as they outline possible connections between the built environment and health. Some of the meditating factors and downstream pathways are obvious: vehicle emissions, exposure to air pollution, and respiratory health; traffic congestion and noise, stress, and chronic diseases; and poorly maintained neighborhoods, crime, and homicides. Others are less direct but increasingly recognized as important, such as the relationships of land use patterns to human activity patterns and obesity-related diseases. In this research, we apply

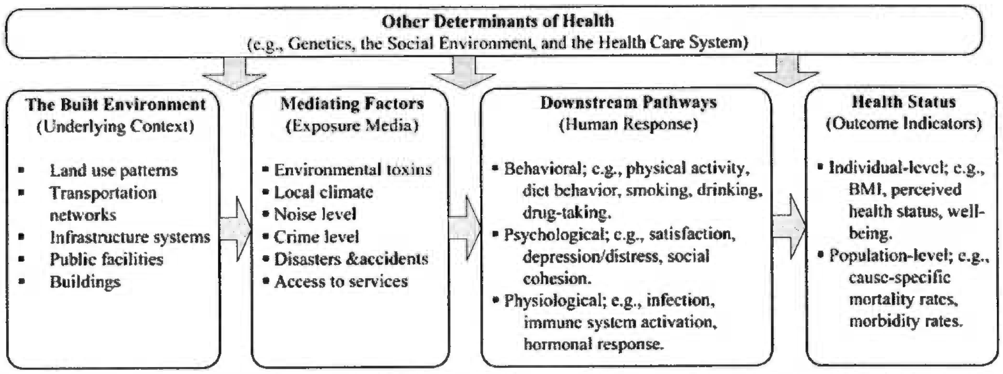


**FIGURE 1.** A conceptual model of how the built environment impacts health. The model presented in this figure is adapted from a conceptual model developed by Klitzman et al.[16] The model has been modified to highlight the mediating factors and downstream pathways by which the built environment influences health outcomes.

the conceptual framework in Figure 1 to study how sprawl may contribute to urban–suburban health disparities in cause-specific mortality.

Sprawl is the prevailing land development pattern in the US, featured by low development density, segregated land uses, lack of significant centers, and poor street connectivity. Sprawl is found to be associated with higher levels of environmental pollution.[17,18] Thereby, according to Figure 1, residents living in sprawling metropolitan areas may experience higher levels of physical, chemical, and biological exposure and are likely to have elevated mortality risks from tumor, infection, or respiratory diseases. Sprawl is also found to be associated with a sedentary lifestyle, unhealthy eating habits, and risk behaviors such as smoking,[19–21] and based upon the downstream pathways illustrated in Figure 1, sprawl may lead to a higher mortality risk from cardiovascular/heart diseases. In addition, sprawl promotes extensive auto use and increases social polarization among communities, which may increase crime rates, worsen traffic conditions, and make residents more vulnerable to external causes of death.[22,23]

Having highlighted the underlying causes of death that are most relevant to health threats associated with sprawl, it is important to note that, within a metropolitan area, the health threats associated with sprawl are likely to affect urban residents disproportionately compared to suburban residents. Sprawl inevitably leads to decentralization and fragmentation of economic opportunities, dramatic reductions in population size, density, diversity, and resources in urban areas, and deprivation of economic, social, and political capitals in inner-cities, all of which create urban–suburban health disparities and increase excess mortality risks among urban residents. In contrast, compact development (i.e., the opposite of sprawl) promotes "smart growth"* and often has goals targeted to prevent

*"Smart growth" is antisprawl development that values long-range, holistic considerations of environmental protection, economic growth, and social equity over short-term fiscal considerations. The term of "smart growth" is often used interchangeably with "growth management." Examples of growth management/smart growth strategies include (a) urban containment boundaries that direct urban development into areas intended or needed for urban uses and protect rural land from urban spillovers, (b) capital improvements programming and adequate facilities standards that discourage developments farther away from existing civil infrastructure systems and encourage infill and redevelopments, (c) land preservation techniques (e.g., transfer of development rights and agriculture/forest buffers) that protect resource land from urban development pressures, etc.

decentralization of economic opportunities, avoid inner-city decline, and advocate compact, transit-oriented, walkable, and bicycle-friendly land uses.[24] These policies embrace geographic equity and promote a more balanced allocation of resources within the metropolitan area between inner-cities and suburbs. Therefore, it is expected that sprawling regions may observe not only higher overall mortality rates but also a wider mortality gap between urban and suburban residents when compared to compact regions.

This paper presents a direct effort to test this a priori expectation. To ensure the robustness and thoroughness of the empirical test, two datasets are employed in this paper: one has cross-sectional population, mortality, and urban form information in the nation's 65 largest metropolitan areas from the year 2000; another has longitudinal population, mortality, and urban form information from 1989 to 2000 in the Portland metro's 71 zip code areas. Analysis of the national dataset attempts to quantify the size variation in urban–suburban mortality gaps across different metropolitan areas and how the magnitude of mortality gaps varies as a function of the extent of sprawl. Analysis of the Portland dataset comes with a longitudinal design that examines whether Portland's recent efforts on curbing sprawl are associated with decreases in urban–suburban health disparities. The two analyses complement each other and are intended to provide supporting empirical evidence on the hypothesis that sprawl is positively linked to the level of urban–suburban health disparities.

## NATIONWIDE CROSS-SECTIONAL STUDY: DATA, METHOD, AND FINDINGS

This national study focuses on the 100 largest metropolitan areas during the year 2000. Boundaries of the metropolitan areas are specified using the Core Based Statistical Areas system defined by the U.S. Office of Management and Budget (OMB) in 2000. According to the US OMB, each metropolitan area consists of one or more counties, encompassing (1) the counties containing a core urban area of 50,000 or more population and (2) any adjacent counties that have a high degree of social and economic integration with the urban core. This operational definition offers opportunities of applying a parallel-group design (i.e., matched pairs of core urban versus suburban counties) to examine urban–suburban mortality gaps.

The final sample of this research is limited to 65 metropolitan areas because of data availability and matching suitability of county components in each metro. Single-county metros are either excluded from the sample (e.g., El Paso, TX and San Diego, CA) or combined into adjacent metros (e.g., the Oakland metropolitan area in CA is combined into the San Francisco metropolitan area). The final 65 metro areas in the sample, as shown in Figure 2, include a total of 458 counties. The 458 counties are categorized into core urban versus suburban counties based upon their urbanization level. Counties are coded as core urban counties if they are identified as large central counties in the 2006 Urban–Rural Classification Scheme by the National Center for Health Statistics (NCHS). If no counties in a metropolitan area are coded as large central by NCHS, counties with the largest city population in the metropolitan area are identified as the urban core county. For example, in the Portland metropolitan area, Multnomah County is identified as the core urban county while Washington, Clark, and Clackamas Counties are identified as suburban counties. Finally, 79 counties are identified as core urban counties and 379 are identified as suburban counties.

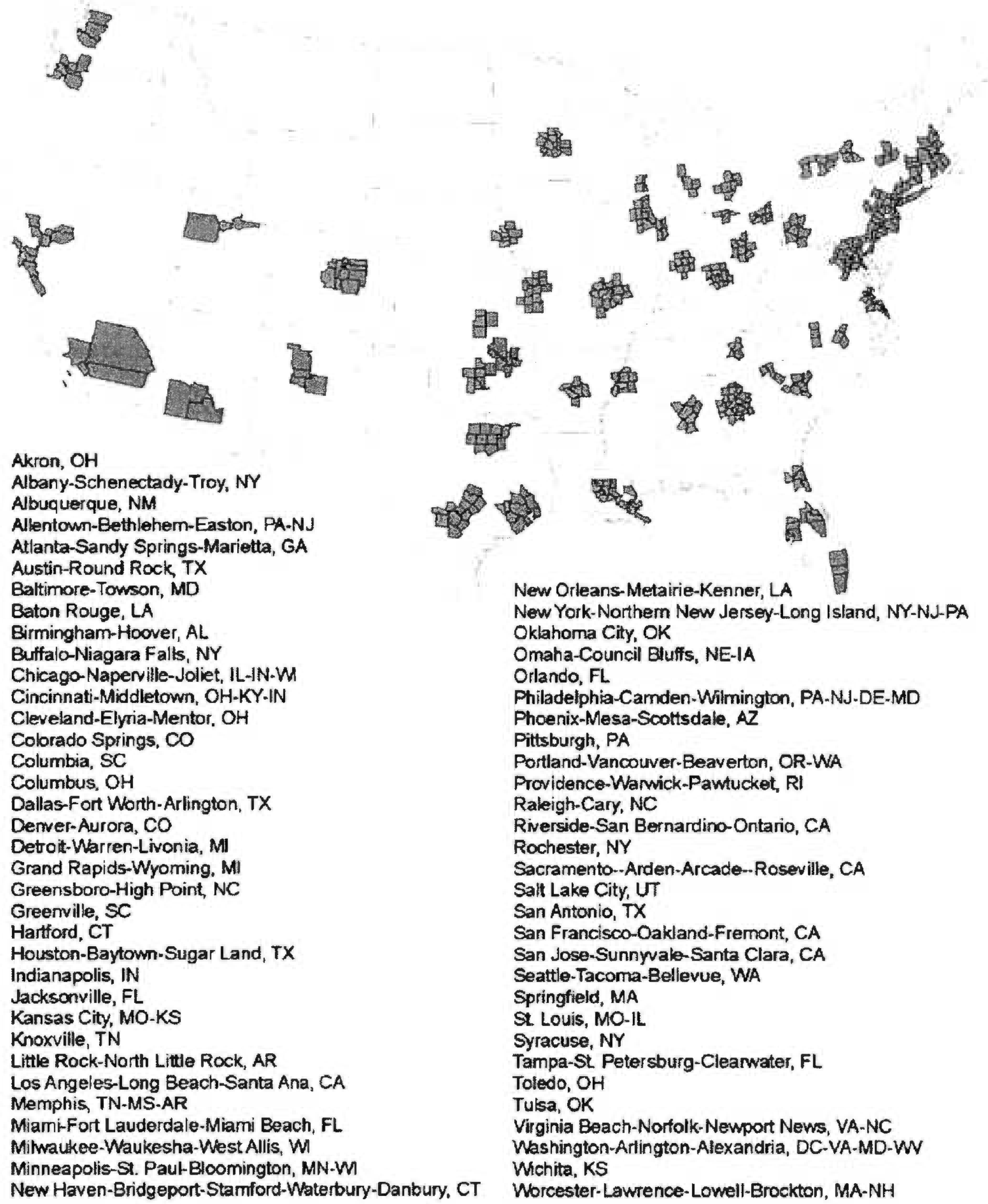


**FIGURE 2.** Study area: 65 metro areas.

## Data and Variables

County-level mortality data come from the Centers for Disease Control and Prevention (CDC). Using the online CDC WONDER platform, 2000–2005 mortality counts by underlying cause of death in the 458 study counties are acquired. As discussed in the "Introduction" section, we highlight the underlying causes of death that are most relevant to health threats associated with sprawl. They are (1) infections, (2) tumors, (3) cardiovascular diseases, (4) respiratory diseases, and (5) external causes such as injury, suicide, and homicide. Cause-specific mortality rates are identified using the International Classification of Diseases (ICD) published by the World Health Organization. To date, there have been ten revisions of the ICD. ICD-9 was used from 1979 to 1998 and ICD-10 has been used

**TABLE 1 ICD codes for five specific underlying causes of death**

| Causes of death | ICD-9 (1979–1998) | ICD-10 (1999–present) |
|---|---|---|
| Certain infectious and parasitic diseases | 001-139 | A00-B99 |
| Neoplasms/tumors | 140-239 | C00-D48 |
| Heart diseases/diseases of the circulatory system | 390-459 | I00-I99 |
| Diseases of the respiratory system | 460-519 | J00-J98 |
| External causes of morbidity and mortality | E800-E899 | V01-Y98 |

since 1999. Table 1 presents the ICD-9 and ICD-10 codes corresponding to each of the five death causes.

Sociodemographic information at the county level comes from the U.S. Census Bureau, including age, sex, race, ethnicity, marital status, income level, and poverty. Furthermore, a set of dummy variables are created to capture contextual differences such as weather and climate in the nine census divisions (i.e., New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, West Mountain, and West Pacific).

A sprawl indicator at the metropolitan level is incorporated into mortality models. Metropolitan-level sprawl indices have been developed by many sources, including USA Today, Sierra Club, and independent researchers (for example, Galster et al.).[25] This paper adopts the sprawl index developed by Ewing et al. for 83 US metropolitan areas because Ewing's index is the most recent and comprehensive effort of measuring sprawl,[26] incorporating various density, land use mix, centrality, and street connectivity dimensions. Ewing's sprawl index is a metropolitan-level factor extracted from six variables through principle component analysis: (1) gross population density (persons per square mile); (2) percentage of population living at low suburban densities; (3) percentage of population living at moderate to high urban densities; (4) net density in urban areas; (5) average block size; and (6) percentage of blocks with areas less than 1/100 square mile. This factor was transformed to a scale with a mean of 100 and a standard deviation of 25. Larger values of the sprawl index indicate more compact metro areas, whereas smaller values indicate more sprawling metro areas. The addition of Ewing's sprawl index to the national dataset allows us to examine whether Seattle (sprawl index=100.9) would have smaller urban–suburban mortality gaps if it were as compact as Portland (sprawl index=126.0) after controlling for sociodemographics.

### Regression Model

At the first glance, Poisson regression is appropriate for this analysis because our dependent variables are mortality rates. However, descriptive analysis shows overdispersion in all-cause and cause-specific mortality rates, which contradicts the assumption of Poisson distribution (i.e., the assumption that the mean is equal to the variance). To address this issue, we estimate mortality models using generalized linear models (commonly referred to as GLZ)**—an approach that places fewer restrictions on model parameters. The GLZ approach allows the variance to be adjusted independently of the mean and thereby relaxes the requirement of equality

**The Generalized Linear Model (GLZ) is an extension of the General Linear Model (GLM) to be used when response variables follow distributions other than the normal distribution and when variances are not constant.

or constancy of variances in traditional Poisson regression. The specification of the GLZ model is shown below. An interaction term between the urban dummy variable and the sprawl index is added to the model to test the hypothesis that the urbanicity-related excess mortality is more evident in sprawling metros than in compact metros. In other words, inclusion of the interaction term allows us to infer whether the level of urban–suburban health disparities within a metropolitan area changes with the area's sprawl magnitude. Control variables of the model include age, gender, race, ethnicity, income, and geographical division. The standard errors in the model are adjusted to correct for correlation among counties in the same metropolitan area:

$$\ln\{E(Y)\} = \beta_0 + \beta_1 X_{Urban} + \beta_2 X_{Sprawl} + \beta_3 X_{Urban} X_{Sprawl} + \beta_C X_{Controls} + \varepsilon, \quad y \sim Poisson$$

where $Y$ is the all-cause or cause-specific mortality rates within each study county in 2000–2005 (unit: deaths per person-year), $X_{\mathbf{Urban}}$ is the dummy variable as 1 represents core urban county and 0 represents suburban county, $X_{\mathbf{Sprawl}}$ is the sprawl index score, $X_{\mathbf{Urban}}X_{\mathbf{Sprawl}}$ is the interaction term of the urban dummy and the sprawl index, $X_{\mathbf{Controls}}$ is a set of control variables including age, gender, race, ethnicity, income, and geographical division, $\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$, and $\beta_C$ are regression coefficients, and $\varepsilon$ is the error term.

Overall, this analysis has a national scope that improves generalizability and uses a parallel-group design that prevents the metropolitan-level environmental context from confounding the impact of urban residence on health. In addition, integrating spatial factors such as the extent of sprawl into cross-sectional mortality models helps to understand the impact of sprawl on urban–suburban health disparities. It is expected that urban–suburban mortality gaps are more evident in sprawling metros than in compact ones.

## Findings

Table 2 presents descriptive statistics on the variables used in the national study. Core urban counties and suburban counties differ with regard to crude mortality rates, population composition, and socioeconomic level. In core urban counties, the percentage of individuals aged 18–29 years tends to be higher. Population in suburban counties (median age=36 years) are generally older than those in core urban counties (median age=34 years). The population size and diversity of suburban counties are much lower than urban counties. Suburban counties on average have higher income levels than their urban counterparts.

In addition, Table 2 shows that all-cause mortality rates are higher in core urban counties, but when looking at cause-specific mortality rates, excess mortality among urban residents does not exist in any of the five cause-specific categories. While death rates associated with infectious and cardiovascular diseases are higher in core urban counties, death rates associated with tumor, respiratory, and external causes are lower in urban counties.

The discrepancy in mortality rates between urban and suburban counties presented in Table 2 does not adjust for demographic composition and socioeconomic characteristics. Table 3 presents the regression results from the estimated GLZ, which controls for sociodemographic confounding factors.

The results in Table 3 show that, after adjusting variations in age, race, ethnicity, income, and regional location, the urban dummy variable is significant and positive in all of the mortality models except the external cause model. Among the

**TABLE 2 Demographic composition, socioeconomic characteristics, and mortality rates by urbanicity**

| | Core urban counties ($N=79$) | | | | Suburban counties ($N=379$) | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Mean | SD | Min | Max | Mean | SD | Min | Max |
| County-level mortality rates (deaths per 1,000,000 persons per year) | | | | | | | | |
| All-cause | 8,267 | 1,774 | 4,741 | 13,357 | 8,111 | 2,097 | 2,510 | 15,339 |
| Cause-specific | | | | | | | | |
| Infectious | 282 | 160 | 79 | 1,085 | 190 | 86 | 33 | 658 |
| Tumors | 1,904 | 396 | 1,072 | 3,018 | 1,944 | 471 | 674 | 4,018 |
| Cardiovascular | 2,997 | 737 | 1,530 | 4,637 | 2,960 | 936 | 719 | 6,696 |
| Respiratory | 753 | 181 | 405 | 1,211 | 789 | 239 | 144 | 1,722 |
| External | 569 | 164 | 306 | 1,177 | 575 | 186 | 211 | 1,215 |
| County-level independent variables | | | | | | | | |
| Population in 2000–2005 (1,000 persons) | 6,940 | 7,828 | 806 | 58,700 | 1,199 | 1,649 | 29 | 11,000 |
| Age under 5 (%) | 7 | 1 | 4 | 9 | 7 | 1 | 3 | 11 |
| Age 5–17 (%) | 18 | 2 | 10 | 22 | 20 | 2 | 7 | 24 |
| Age 18-21 (%) | 6 | 1 | 3 | 11 | 5 | 2 | 3 | 37 |
| Age 22–29 (%) | 12 | 2 | 8 | 19 | 10 | 2 | 6 | 20 |
| Age 30–39 (%) | 16 | 2 | 14 | 23 | 16 | 2 | 8 | 22 |
| Age 40–49 (%) | 15 | 1 | 13 | 17 | 16 | 2 | 8 | 23 |
| Age 50–64 (%) | 14 | 1 | 11 | 17 | 16 | 2 | 10 | 23 |
| Age 65 up (%) | 12 | 3 | 7 | 23 | 12 | 3 | 4 | 31 |
| Median age | 34 | 2 | 29 | 43 | 36 | 3 | 23 | 50 |
| Foreign born (%) | 14 | 11 | 2 | 51 | 5 | 6 | 0 | 32 |
| Hispanic (%) | 14 | 13 | 1 | 57 | 6 | 8 | 0 | 59 |
| Black (%) | 20 | 15 | 1 | 67 | 9 | 12 | 0 | 70 |
| Median family income ($) | 50,933 | 8,961 | 30,682 | 81,717 | 55,281 | 12,825 | 25,443 | 97,225 |

**TABLE 3 Regression results from the national cross-sectional study**

| Variables | Infectious diseases | Neoplasms/tumors | Cardiovascular diseases | Respiratory diseases | External causes | All causes |
|---|---|---|---|---|---|---|
| Interaction term | −0.0024*** | −0.0011*** | −0.0010** | −0.0016** | −0.0004 | −0.0009* |
| Sprawl index | 0.0026*** | 0.0009*** | 0.0005 | −0.0007** | 0.0002 | 0.0005*** |
| Urban dummy | 0.2462** | 0.1104*** | 0.1181** | 0.1539** | 0.0473 | 0.0936** |
| % Age under 5 | −14.9471** | −5.7679*** | −5.2328** | −3.1119** | −7.2509** | −2.8675 |
| % Age 5–17 | −5.9328** | −1.9959** | −4.5074*** | | −3.6170*** | −2.5069** |
| % Age 18–21 | −8.7904*** | −3.5969*** | −5.2944*** | −1.8986** | −5.8741*** | −3.4247*** |
| % Age 22–29 | −6.3232* | −2.4140* | −7.4744*** | | −3.8317*** | −2.3086** |
| % Age 40–49 | | 2.8566*** | 4.3180** | 5.6304*** | | 5.9964* |
| % Age 50–64 | | 6.1889*** | 9.8254*** | 10.7556*** | 3.7620*** | 8.3231** |
| % Age 65 up | 5.9366*** | 8.2364*** | 11.3656*** | 10.5460*** | 3.3174*** | 10.6078*** |
| Median age | −0.1257** | −0.1014*** | −0.1815*** | −0.1300*** | −0.0895*** | −0.1353** |
| % Foreign born | | −0.0074*** | | | −0.0112*** | −0.0065** |
| % Hispanic | | | −0.1556** | −0.6139*** | | |
| % Black | 2.0164*** | 0.2519*** | 0.3211*** | −0.3386*** | 0.5163*** | 0.3269** |
| Family income ($10,000) | −0.0598*** | −0.0289*** | −0.0691*** | −0.0743*** | −0.1215*** | −0.0547*** |
| New England | 0.4612*** | 0.0600*** | | 0.1474*** | −0.1671*** | 0.0479** |
| Middle Atlantic | 0.4688*** | | 0.0566*** | | −0.2482*** | |
| Midwest East | 0.2424*** | | 0.0662*** | | −0.0906** | |
| Midwest West | | −0.0269** | | | | |
| West Mountain | 0.1786** | −0.1633*** | −0.1732*** | | 0.2859*** | −0.1002** |
| South Atlantic | 0.3523*** | −0.0662*** | −0.0806*** | −0.0861*** | | −0.0505*** |
| West South Central | 0.3963*** | −0.0768*** | | −0.1400*** | 0.0767* | −0.0496*** |
| East South Central | 0.2331*** | −0.0503** | | | | |
| Constant | −1.9473 | −3.6682*** | −0.3133 | −5.4057*** | −2.7010 | −2.0958*** |
| Summary statistics | | | | | | |
| *N* | 458 | 458 | 458 | 458 | 458 | 458 |
| LR statistic | 2,657.87 | 4,738.90 | 2,855.05 | 1,544.17 | 2,219.10 | 6,430.52 |
| *P* (alpha) = ~0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Among age groups, "% Age 30–39" is the reference age category. Among census divisions, West Pacific is the reference category. Variables were excluded from models if they are not significant at the 0.1 level

$^{*}p<0.10$; $^{**}p<0.05$; $^{***}p<0.01$

five cause categories, infectious diseases are associated with the highest excess mortality among urban residents (indicated by a coefficient of 0.2462), followed by respiratory diseases (0.1539), tumors (0.1181), cardiovascular diseases (0.1104), and external causes (0.0473). The coefficient of 0.2462 on the urban dummy variable in the mortality model of infectious diseases translates to an incident rate ratio of 1.279 (1.279=exp(0.2462)). This indicates that, while holding other variables constant and the sprawl index at 0 (note that a 0 value on the sprawl index indicates the highest level of sprawl), residents in core urban counties on average have an infection-related mortality risk 27.9% ($p<0.01$) higher than those in suburban counties. In the all-cause mortality model, the urban dummy variable has a coefficient of 0.0936, indicating that, while holding other variables constant and the sprawl index at 0, the overall mortality risk in core urban counties on average is about 10% ($p<0.05$) higher than that of suburban counties (10% = 100% × exp(0.0936) − 100%). Likewise, in the most sprawling metropolitan areas where the sprawl index is close to 0, urban residents on average have 11.7% higher risk of tumor-caused death, 12.5% higher risk of cardiovascular mortality, and 16.6% higher risk of respiratory mortality than suburban residents.

More interestingly, coefficients on the sprawl index show that, while infection-realted and tumor-related mortality is positively associated with ($p<0.01$) the sprawl index, respiratory diseases-related mortality is negatively associated with ($p<0.05$) the sprawl index. As lower sprawl index values represent more sprawling metros, the results indicate that when holding other variables constant and holding the urban dummy at 0 (note that the unit of analysis is the county and a 0 value on the urban dummy variable indicates the county to be a suburban county), suburban counties in compact metros have higher infection-related and tumor-related mortality but lower respiratory-related mortality than suburban counties in sprawling metros. The sprawl index in models for cardiovascular diseases and external causes is not significant. This is consistent with our earlier expectation that sprawl impacts health in a cause-specific way.

Negative coefficients on the interaction term provide evidence in support of our earlier hypothesis: urban–suburban health disparities are more evident in sprawling metros than metros implementing smart growth policies. Coefficients on control variables show consistency with previous studies on mortality. Poorer areas with more elderly and African Americans generally have higher mortality rates. In terms of regional location, the New England division has the highest mortality rates caused by infectious diseases, tumors, and respiratory diseases while the West Mountain division has the lowest. For external causes, the New England division has the lowest mortality rate while the West Mountain division has the highest. For all-cause mortality, New England has the highest and West Mountain has the lowest.

To gain a better view of how urban residence, sprawling land use patterns, and their interaction may affect mortality rates, we estimate all-cause and cause-specific mortality rates and the uncertainty surrounding them for urban versus suburban counties across the range of the sprawl index, while holding other variables at their median values. Statistical software packages including Clarify 2.0 and Stata 8.0 are used to estimate the expected values and their uncertainty.[27] For the case of a typical core urban county and the other case of a typical suburban county, expected value algorithm is repeated to approximate 90% confidence interval around mortality rates. We then plot the estimated expected values and the range of uncertainty in Figure 3, which illustrates the regression findings in Table 3 quite sharply. That is, the urban–suburban mortality gap, illustrated by the distance between blue dashed lines and black solid lines,

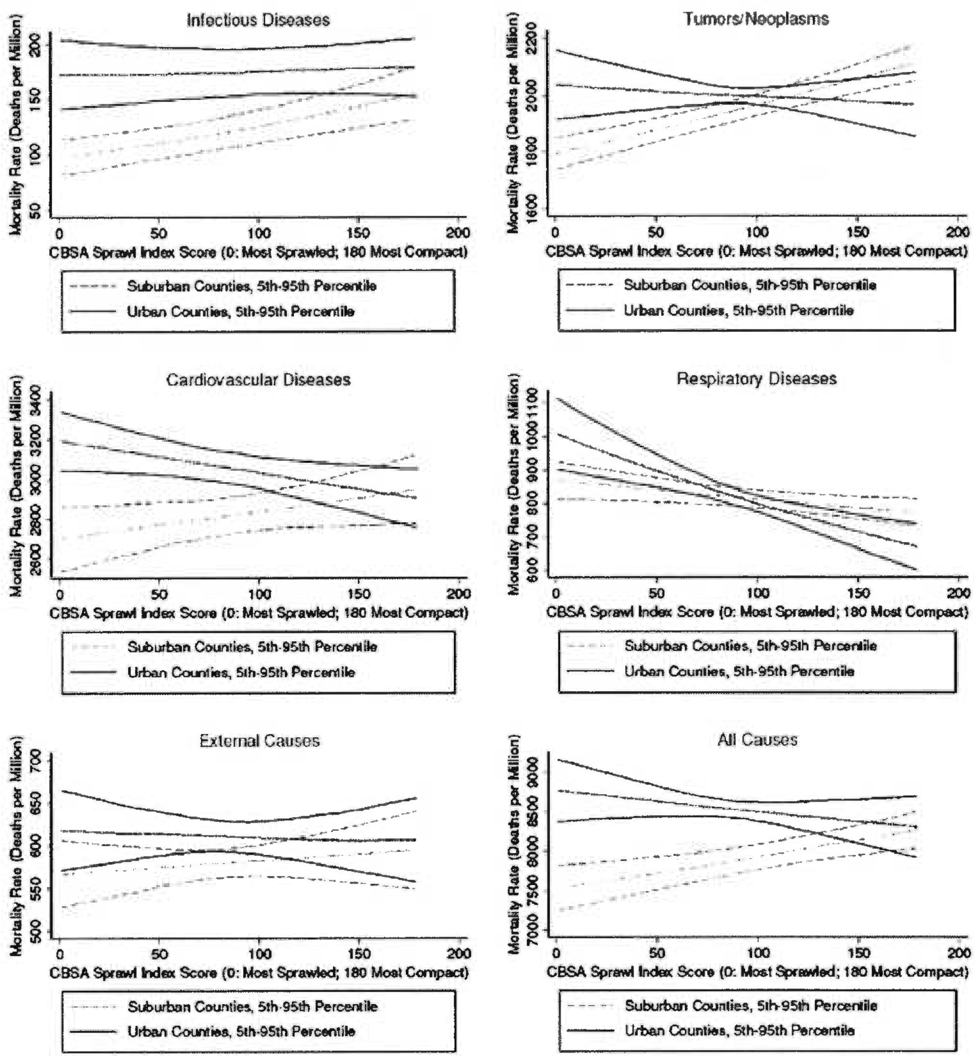


**FIGURE 3.** Mortality rates by the sprawl index and place of residence.

generally shrinks as the sprawl index increases (i.e., the built environment becomes less sprawling). Figure 3 shows that, in the most sprawling metros (sprawl index=0), mortality rates in core urban counties are significantly higher than those of suburban counties. In the least sprawling metros (sprawl index=180), no significant differences in mortality rates can be detected between core urban and suburban counties.

More specifically, in the U.S. most sprawling metros (e.g., Riverside, CA where the sprawl index score is 14.22), health disparities burdening urban residents ( or the urban health penalty) translate to approximately 75 deaths per million persons caused by infectious diseases, approximately 200 deaths per million population caused by tumors/neoplasms, approximately 500 deaths per million caused by cardiovascular diseases, and approximately 100 deaths per million population caused by respiratory diseases. In terms of overall mortality, in the most sprawling metros, the model predicts an excess mortality of 1,300 deaths per million in core urban counties compared to suburban counties, after adjustment for socioeconomic characteristics and demographic composition. For less sprawling metros, Figure 3 shows converging confidence intervals between urban and suburban counties, indicating little urban–suburban mortality differentials in metropolitan areas with compact development patterns. Among the five cause categories, only the model for external causes predicts neither urban–suburban mortality differences nor interaction between sprawl and urban–suburban health disparities. Evidence from all other models supports the association between sprawl and widening urban–suburban mortality gaps and that such mortality gaps mainly present an urban health penalty. This further indicates that health threats associated with sprawl tend to impact urban residents disproportionately compared to suburban residents.

## PORTLAND LONGITUDINAL STUDY: DATA, METHOD, AND FINDINGS

We choose Portland as the study area for our longitudinal study mainly because of Portland's recent success in reversing the trend of urban sprawl.[28] Portland, a living laboratory for efficient urban planning and living, is perhaps best known for its urban growth boundary (UGB) and its light rail system. The UGB was established in 1979 and has expanded little since then. Under the requirements of Oregon's land use statutes, all land outside the UGB—with exceptions—is designated for resource use and prohibited from urban development. All land both inside and outside the UGB must be planned by the appropriate city or county and implemented with corresponding zoning. Proponents argue that Portland's UGB has successfully served to contain urban sprawl.[29] In addition, Portland has adopted a set of plans to encourage a compact urban growth pattern. In 1995, the Portland Metro Council adopted the 2040 growth concept, which calls for putting newcomers into dense, mixed-use neighborhoods; developing vacant land inside the growth boundary into relatively dense residential areas; encouraging developers to take advantage of higher-density zoning, to redevelop existing neighborhoods, and to "infill" vacant lots; and increasing the share of multifamily housing. The adopted growth concept was fleshed out into a comprehensive "regional framework plan" by the end of 1997. The regional framework plan allocates Portland neighborhoods to such categories as "regional centers," "town centers," "corridors," and "inner" and "outer neighborhoods."[30] Furthermore, Portland's light rail transit system was established on the east side of the metropolitan area in 1986 and expanded on the west side in 1998. The light rail transit system runs along the corridors and connects the centers. Additionally, transit area overlay zones with minimum density requirements and several public/private partnerships are established to encourage high-density housing and employment growth around station areas. Proponents claim that the system has been an effective vehicle for creating a less auto-dependent urban development pattern.[31]

The fact that Portland's major growth management/smart growth efforts started in the late 1980s and became more evident in the 1990s offers an opportunity to perform hypothesis-driven research with a before-and-after design. Song and Knaap's study found out that several smart urban development elements including more connective neighborhoods and more accessible public transit happened since the early 1990s.[28] However, time lags must be considered when looking at the impact of the built environment on health outcomes. Evident changes in health outcomes are likely to begin in mid-1990s. To find the most appropriate intervention year, we tried 1993, 1994, and1995 when conducting before-and-after comparisons. The year of 1994 appears to have the most evident changes in mortality rates and thereby we use 1994 as the division line defining the before and after periods. If the smart growth movement in the Portland metro area has played a role in mitigating urban–suburban health disparities, smaller mortality gaps between urban and suburban residents are expected in the period after smart urban development than in the period before.

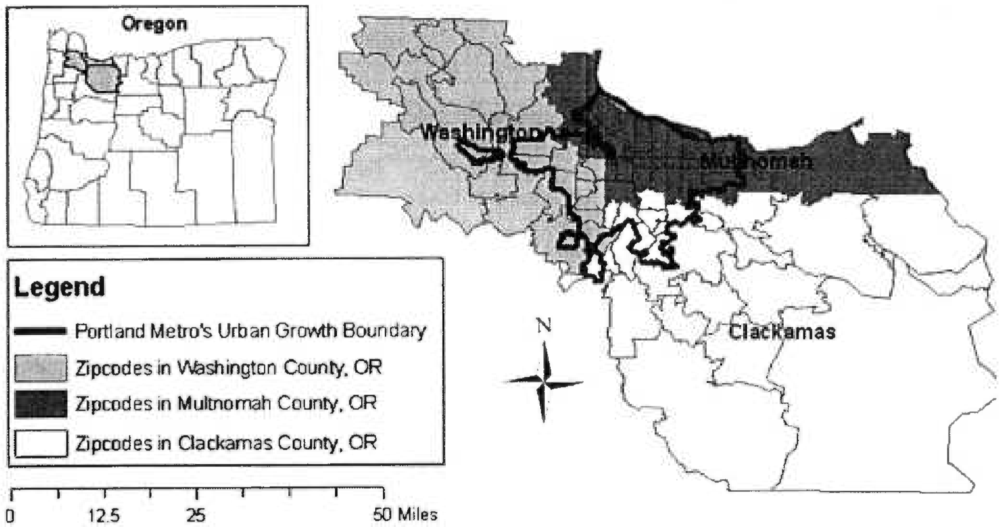


**FIGURE 4.** Study area: 71 zip codes in the Portland metropolitan area.

Due to issues in data availability, the study area comprises three out of the four counties in the Portland metropolitan area, including Washington, Multnomah, and Clackamas Counties in Oregon. Figure 4 shows the UGB and the 71 zip code areas in the three counties.

### Data and Variables

The mortality data used in this study come from death certificates collected by the Oregon Center of Health Statistics in years from 1989 to 2000. The 1989–2000 death certificates provide individual information on causes of death, year of death, and residency identified by zip code. We aggregated the individual mortality data by year of death and zip code, resulting in a total of 142 data points (i.e., 71 mortality rates at the zip code level in the before period and another 71 in the after period). As the ICD codes for underlying causes of death changed in 1999, bridging codes in Table 1 are used to convert ICD-9 to ICD-10.

Population density at the zip code area level is used to quantify urbanicity—the degree to which a geographical unit is urban. All-cause and cause-specific mortality rates are regressed on the urbanicity indicator, a dummy code of time intervals, and an interaction term between them to quantify how the effect of urbanity on mortality rates changed over time, while controlling for sociodemographic composition of the zip code area. Census 1990 and 2000 data are used to generate values on population density and control variables, respectively, in the before (1989–1994) and after (1995–2000) periods.

### Regression Model

GLZ are used again to model zip code-level mortality rates in the before and after periods. The model specification is shown below. The standard errors in the model are adjusted to correct for the correlation between before and after periods in the same zip code area:

$$\ln\{E(Y)\} = \beta_0 + \beta_1 X_{Urban} + \beta_2 X_{After} + \beta_3 X_{Urban} X_{After} + \beta_C X_{Controls} + \varepsilon, \quad y \sim Poisson$$

where $Y$ is the all-cause or cause-specific mortality rates within the specific time period in the zip code area (unit: deaths per person-year), $X_{\mathbf{Urban}}$ is the urbanicity indicator represented by the population density at the zip code area level (unit: 100

**TABLE 4 Before-and-after comparisons of demographic composition, socioeconomic characteristics, and mortality rates in the Portland metropolitan area**

| | 1989–1994 (*N*=71) | | | | 1995–2000 (*N*=71) | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Mean | SD | Min | Max | Mean | SD | Min | Max |
| Zip code-level mortality rates (deaths per 1,000,000 persons per year) | | | | | | | | |
| All-cause | 8,814 | 4,420 | 265 | 26,846 | 7,725 | 2,806 | 1,414 | 18,113 |
| Cause-specific | | | | | | | | |
| Infectious | 240 | 263 | 0 | 1,178 | 172 | 170 | 0 | 1,218 |
| Tumors | 2,116 | 1,149 | 0 | 8,501 | 1,785 | 559 | 202 | 2,967 |
| Cardiovascular | 3,387 | 1,606 | 139 | 10,067 | 2,800 | 999 | 404 | 5,627 |
| Respiratory | 834 | 398 | 0 | 1,854 | 716 | 284 | 0 | 1,370 |
| External | 334 | 280 | 6 | 2,122 | 334 | 355 | 72 | 2,892 |
| Zip code-level independent variables | | | | | | | | |
| Population density (person/square mile) | 2,292 | 2,491 | 5 | 11,799 | 2,645 | 2,652 | 11 | 13,322 |
| Age under 5 (%) | 7 | 2 | 0 | 11 | 6 | 2 | 0 | 9 |
| Age 5–17 (%) | 18 | 5 | 0 | 29 | 18 | 5 | 1 | 25 |
| Age 18–29 (%) | 17 | 5 | 3 | 36 | 17 | 5 | 8 | 33 |
| Age 30–49 (%) | 34 | 4 | 25 | 43 | 33 | 4 | 28 | 53 |
| Age 50–64 (%) | 12 | 2 | 6 | 19 | 16 | 3 | 11 | 23 |
| Age 65 up (%) | 12 | 4 | 5 | 33 | 10 | 3 | 5 | 20 |
| Foreign born (%) | 10 | 6 | 0 | 24 | 10 | 6 | 0 | 24 |
| Hispanic (%) | 4 | 3 | 1 | 16 | 7 | 5 | 2 | 25 |
| Black (%) | 3 | 8 | 0 | 47 | 3 | 7 | 0 | 35 |
| Male (%) | 50 | 4 | 44 | 72 | 51 | 4 | 47 | 78 |
| Married HHs (%) | 56 | 16 | 7 | 77 | 51 | 16 | 3 | 75 |
| Median family income ($) | 57,700 | 14,383 | 24,844 | 101,190 | 57,700 | 14,383 | 24,844 | 101,190 |

Both before and after periods use median family income 1999 data downloaded from the Census Bureau because 1999 is the only year where income data are available persons per square mile), $X_{After}$ is the dummy code of time intervals (1 represents the after period from 1995 to 2000 and 0 represents the before period from 1989 to 1994), $X_{Urban}X_{After}$ is the interaction term of the urbanicity indicator and the time dummy, $X_{Controls}$ is the set of control variables including age, sex, race, ethnicity, marital status, and income, $\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$, and $\beta_C$ are regression coefficients, and $\varepsilon$ is the error term.

## Findings

Table 4 provides descriptive statistics of various variables in the before and after periods in Portland metro's 71 zip code areas. On average, when comparing the after period (1995–2000) with the before period (1989–1994), the Portland metro experienced a drop in all-cause mortality from 8,814 to 7,725 deaths per million persons per year. Mortality rates of the five cause-specific categories all decreased over time except externally caused mortality. However, without adjustment for demographic composition and socioeconomic characteristics and without relating mortality rates to urbanicity, decreases in crude mortality rates provide insufficient evidence that mortality risks among Portland residents have declined in the past decade.

Descriptive statistics in Table 4 also show time variations in Portland's demographic composition. During the past decade, the Portland metro became more populated and attracted more Hispanic/Latino immigrants. The area saw moderate changes in age distribution. The 50–64 age group increased from 12% in 1990 to 16% in 2000 while the 65+ age group decreased from 12% to 10%. Percentage of married households dropped from 56% in 1999 to 51% in 2000. The gender distribution did not change much in the Portland metropolitan area during the past decade. Large standard deviations and wide ranges shown in Table 4 suggest that substantial variation in mortality rates and sociodemographic attributes exists at the zip code area level.

Table 5 presents regression results from the Portland longitudinal study. Results suggest that, after adjustments for sociodemographic characteristics at the zip code area level, urbanicity-related excess mortality is only observed in the infection category. Only infection-caused mortality is positively related to the urbanicity factor measured by population density, shown by a positive regression coefficient of 0.0052. Coefficients on the urbanicity factor in other models are all negative and significant, indicating that all-cause mortality rates and most cause-specific rates such as tumor, cardiovascular and respiratory diseases, and external causes decrease as the urbanicity of a zip code area increases. In other words, in 1989–1994, Portland not only experienced an urban health penalty (indicated by results from the model for infectious diseases) but to some degree also experienced an urban health advantage (indicated by other models).

Coefficients on the time dummy variable are negative and significant in all the models, indicating that, while holding other variables constant, all-cause and cause-specific mortality rates decreased over time. This finding supports our early expectation that Portland's extensive efforts on curbing sprawl are associated with net decreases in the metro's mortality rates. Coefficients on the interaction term between time and urbanicity show different directions and magnitudes across the six models. However, the interaction term in each of the six models always has a different sign from the urbanicity factor. This pattern suggests narrowed urban–suburban mortality gaps (either urban penalty or advantage) in the after period. For example, in the infectious diseases model, the positive coefficient on the urbanicity

**TABLE 5 Regression results from the Portland longitudinal study**

| Variables | Infectious diseases | Neoplasms/tumors | Cardiovascular diseases | Respiratory diseases | External causes | All causes |
|---|---|---|---|---|---|---|
| Interaction term | −0.0034* | 0.0022** | 0.0019** | 0.0016 | 0.0021 | 0.0015* |
| Time dummy (1 if 1995–2000) | −0.2763** | −0.2953*** | −0.4344*** | −0.2318*** | −0.2084*** | −0.2249*** |
| Urbanicity (100 persons per square mile) | 0.0052** | −0.0027** | −0.0025* | −0.0034** | −0.0058*** | −0.0029** |
| % Age under 5 | −7.9326 | | | | | |
| % Age 5–17 | −8.6266*** | 2.5206** | 2.5276** | 3.3382** | | 1.6508* |
| % Age 50–64 | −5.0240** | 3.9351*** | 3.8088*** | 2.5325* | | 2.7417*** |
| % Age 65 up | | 5.3751*** | 5.0376*** | 5.7367*** | 3.4160*** | 5.0588*** |
| % Black | 2.6545*** | | −0.6831** | −1.1124*** | | |
| % Hispanic | 3.2915*** | | 1.8667*** | | | |
| % Male | −3.4285*** | | −2.5747** | | 4.4830*** | |
| Median Family income ($10,000) | −0.0589** | −0.0554*** | −0.0816*** | −0.1044*** | −0.1484*** | −0.0778*** |
| % Foreign born | −0.0210* | | −0.0131** | | −0.0203*** | |
| % Married HH | | −1.5021*** | −2.0467*** | −2.2834*** | −1.5562*** | −1.7320*** |
| Constant | −3.9847*** | −6.5735*** | −4.2244*** | −6.7634*** | −8.7491*** | −4.5714*** |
| Summary statistics | | | | | | |
| *N* | 142 | 142 | 142 | 142 | 142 | 142 |
| LR statistic | 573.43 | 319.34 | 347.07 | 249.80 | 232.29 | 337.30 |
| *P* (alpha) = ~0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Among age groups, "% Age 18–49" is the reference age category. Variables were excluded from models if they are not significant at the 0.1 level
*$p<0.10$; **$p<0.05$; ***$p<0.01$

factor suggests an urban health penalty in the before period and the negative coefficient on the interaction term suggests a decline of the urban health penalty over time. This further indicates that Portland's efforts on curbing sprawl are associated with mitigated urban–suburban health disparities.

Most coefficients on control variables show consistency with previous mortality studies. Poorer areas with more elderly and African Americans generally have higher mortality rates. Areas with higher ratio of married households are generally associated with lower mortality rates. Furthermore, larger male population is associated with higher externally caused mortality but lower infection-caused and cardiovascular-related mortality.

To better understand how the time and urbanicity factors affect health outcomes, all-cause and cause-specific mortality rates and the uncertainty surrounding them are estimated for the before versus after periods across the range of urbanicity, while holding other variables at their medians. For a typical zip code area in the before period (1989–1994) and a typical zip code area in the after period (1994–2000),

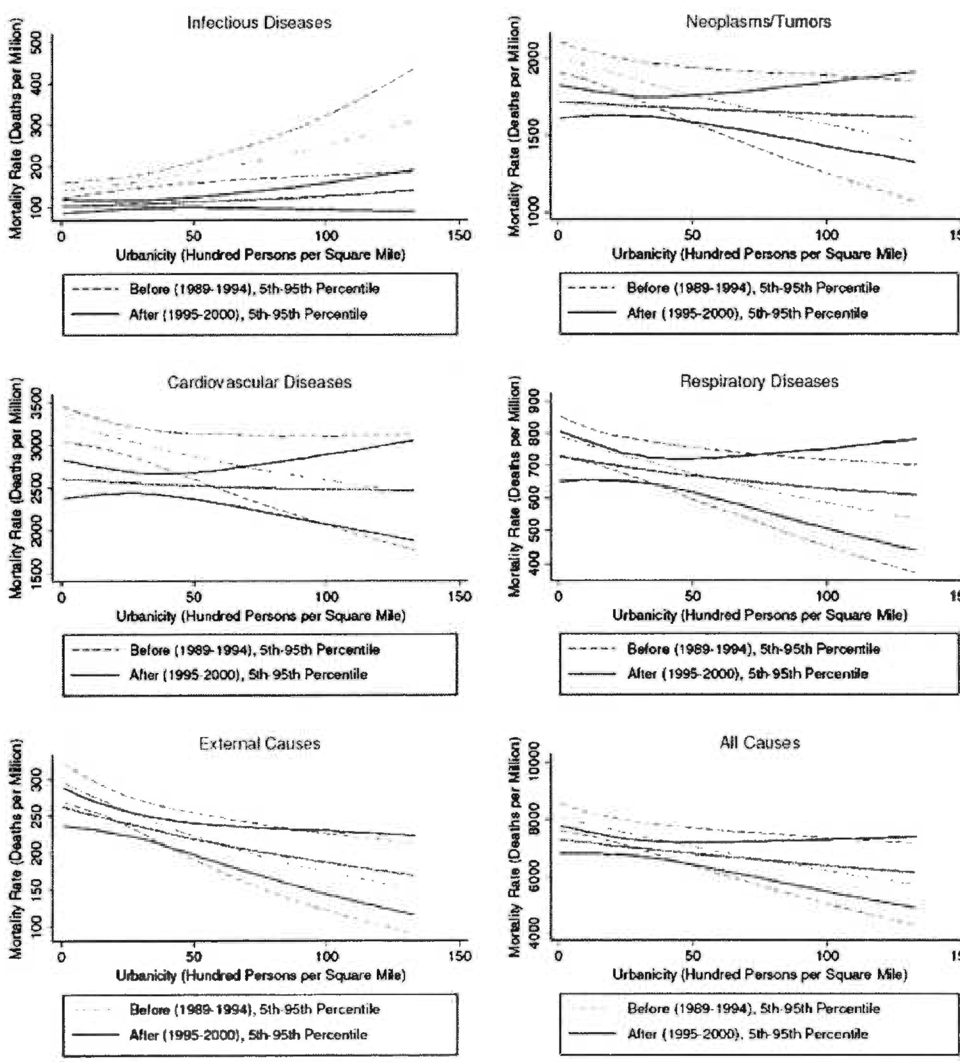


**FIGURE 5.** Mortality rates by time and urbanicity.

expected value algorithm is repeated to approximate how the 90% confidence interval of mortality rates changes by urbanicity. Statistical software packages including Clarify 2.0 and Stata 8.0 are used again to estimate the expected values and their uncertainty. The estimated results are visually presented in Figure 5.[27]

Figure 5 reinforces the regression findings presented in Table 5. Lines presenting the before period (blue dashed lines in Fig. 5) has steeper increasing or declining trends than the lines presenting the after period (black solid lines). This indicates that, in years 1989–1994, urbanicity-related mortality gaps existed in the Portland metro (i.e., area-based mortality rates change as urbanicity varies). However, urban–suburban mortality gaps existed in years 1989–1994—either urban penalty or advantage—all became less evident in the after period (1994–2000). Furthermore, Fig. 5 shows upward lines when relating infection-caused mortality to urbanicity but downward trends when relating other mortality rates to urbanicity. This suggests that, while the model for infectious diseases predicts excess mortality among urban residents in the Portland metropolitan area, all other models predict elevated mortality among suburban residents in the metro.

## CONCLUSIONS AND DISCUSSION

In this paper, we examine whether sprawl is associated with a wider mortality gap between urban and suburban residents. Our national cross-sectional study and Portland longitudinal study provide the only evidence to date that (1) across metropolitan areas, the size of urban–suburban mortality gaps varies by the extent of sprawl: in sprawling metropolitan areas, urban residents have significant excess mortality risks than suburban residents, while in compact metropolitan areas, urbanicity-related excess mortality becomes insignificant; (2) the Portland metropolitan area not only experienced net decreases in mortality rates but also a narrowing urban–suburban mortality gap since its adoption of smart growth regime in the past decade; and (3) the existence of excess mortality among urban residents in US sprawling metropolitan areas, as well as the net mortality decreases and narrowing urban–suburban mortality gaps in the Portland metropolitan area, is not attributable to sociodemographic variations. The national and Portland studies, although very different in scope and approach, point to similar directions. Both suggest a positive association between sprawl and urban–suburban health disparities. This further indicates that growth management strategies and policies such as UGB and impact fees may reduce the mortality gap between urban and suburban residents through curbing and preventing sprawl.[32]

When looking at cause-specific mortality, infectious diseases and external causes show unique patterns from all other causes. Excess mortality among urban residents is most evident when examining infection mortality rates, shown by a much larger coefficient on the urban dummy variable in Table 3 and the positive relationship between infectious disease mortality and urbanicity in the Portland study. The high relevance of infection deaths to urbanicity suggests that crowding and density pose health risks to residents, perhaps potentiated by rapid transmission from one person or specie to another in populated urban environments. External causes also show unique mortality patterns. In the national study, the external causes model is the only model that shows no significant association among mortality rates, urbanicity, and sprawl. This finding contradicts the general perception that living in cities is equated with higher risks of accidental deaths due to exposure to more traffic accidents and violent crimes. However, the finding concurs with previous empirical findings.[5,33] A possible explanation is that the model estimates mortality rates rather than the absolute number of deaths and people tend to mistakenly perceive higher risks in cities because of the high absolute number of accidental deaths.

Most importantly, while much research on sprawl has identified negative health consequences of sprawl,[20–22] our research has shown that it is also important to investigate the spatial distribution of health outcomes within the metropolitan area and especially the health disparity issues between central cities and suburbs. By looking at how sprawl and urbanicity may interactively affect mortality, we find that sprawl is associated with not only net mortality increases at the metropolitan level but also wider intrametropolitan mortality gaps between urban and suburban residents. Mortality risks imposed by sprawl affect urban residents disproportionately compared to suburban residents. In other words, this paper provides convincing evidence on the notion "sprawl is bad for health" without contradicting the fact "suburban residents are generally healthier."

Although the research provides a framework for examining the sprawl–health inequity association, the framework is largely preliminary and exploratory and raises important issues for future research. For example, when investigating health disparities burdening urban residents, both measuring health and defining urbanicity determine the results.[34] While level of urbanization can be conveniently used to categorize urban versus suburban areas, this scheme may mask important differences within urban or suburban areas.[35] An attempt should be made to develop alternative measurements of urbanicity. Furthermore, the national mortality analysis is conducted at the county level, which admittedly limits the interpretation of the analysis results. Within the same county, the built environment may vary considerably. Future research may be conducted at more disaggregate levels to develop a finer-grained understanding of how neighborhood-level built environment features may contribute to urban–suburban health disparities. In addition, information on housing location choice among urban/suburban residents may be collected to address self-selection bias—the issue that healthier people select themselves to "healthier" places. Finally, the transferability of findings from our Portland longitudinal study is somewhat limited. Researchers can apply the longitudinal approach to a much larger and more diverse sample of metropolitan areas. We hope that this study will stimulate research on the relationship between sprawl and health disparities.

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# EXHIBIT K

EXHIBIT K

# Quantifying the Impact of Mosquitoes on Quality of Life and Enjoyment of Yard and Porch Activities in New Jersey

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## Abstract

The recent expansion of *Aedes albopictus*, a day-biting mosquito, to densely inhabited areas in the northeastern Atlantic states of the USA has dramatically increased the problem that mosquitoes create for urban and suburban residents. We quantified the impact of mosquitoes on residents' quality of life within the context of a comprehensive area-wide integrated pest management program to control *Ae. albopictus* in two counties (Mercer and Monmouth) in New Jersey. We interviewed residents of 121 randomly selected households in both counties between October and November 2010. We asked residents about their experience with mosquitoes in their neighborhood and the importance of the ability to relax outdoors without mosquitoes compared to other neighborhood characteristics (1 = not important, 5 = extremely important). We rated residents' utility based on paired comparisons to known states from the EuroQol health description system. The majority (54.6%) of respondents considered mosquitoes to be a problem. Respondents reported an average of 7.1 mosquito bites in a typical week during that summer. Mosquitoes prevented 59.5% of residents from enjoying their outdoor activities at least to some extent. Residents rated the mosquito acceptability (mean $\pm$ standard deviation) during that summer on a scale of 0 (mosquito invasion) to 100 (no mosquitoes) at $56.7\pm28.7$, and their overall utility at $0.87\pm0.03$. This is comparable to living with up to two risk factors for diabetes (i.e., abdominal obesity, body mass index of 28 or more, reported cholesterol problems, diagnosis of hypertension, or history of cardiovascular disease) or women experiencing menstrual disorders. Respondents rated the importance of enjoying outdoor activities without mosquitoes ($4.69\pm0.80$) comparable to that of neighborhood safety ($4.74\pm0.80$) and higher than that of a clean neighborhood ($4.59\pm0.94$). In conclusion, New Jersey residents reported that mosquitoes decreased their utility by 0.13, comparable to the loss from worrisome health risk factors, underscoring the importance of controlling this problem.

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## Introduction

The day-biting mosquito *Aedes (Stegomyia) albopictus* (Skuse) became established in the United States in 1985, appeared in New Jersey in 1995, and is now the primary cause of service requests to local and state mosquito control programs [1]. While the disease risks associated with *Ae. albopictus* and other mosquito species have been extensively studied [2–5], the impact of mosquitoes on residents' quality of life, daily choices, behaviors, and use of resources has been rarely investigated [6,7]. The World Health Organization defined health as "*a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity* [8]." Understanding what factors influence residents' quality of life is important to guide public policy and assist policy makers in planning and allocating scarce public resources in a manner that enhances societal progress and enables the society to function efficiently and smoothly [9].

*Aedes albopictus*, commonly known as the Asian tiger mosquito, is a major concern for public health and mosquito control officials throughout its invasive range [10–12], as it continues to spread to new areas with high human population density [1,4,7,11]. This species is highly adapted to urban and suburban areas, and commonly oviposits eggs in artificial containers [3,13,14]. *Aedes albopictus* is a vector of at least 22 arboviral diseases including dengue, chikungunya, West Nile virus, and yellow fever [15,16]. With the increasing number of travelers to endemic countries diagnosed with arboviral infections, the presence of this species escalates the risk of local transmission of arboviral diseases throughout its range [2,17,18], as observed through autochthonous transmission of dengue and chikungunya in Hawaii, USA [19], France [20], Croatia [21], and Italy [22].

In southeastern Virginia, USA, the nuisance associated with *Ae. albopictus* affected the daily activities of 46.6% of residents, and forced 81.3% of residents to stay indoors due to mosquito bites [7]. In a study in Upper Rhine Valley, Germany, residents' preference for a mosquito control program targeting mosquitoes' nuisance was compared to mosquito control programs with potential economic benefits, such as promotion of gastronomy or tourism, it was found that residents were willing to pay 3.8 times the government's actual cost to control mosquito nuisance [23]. A Wisconsin, USA, study concluded that residents might be willing to pay on average $147 per household per year to reduce mosquito nuisance, compared to only $21 for programs targeting disease transmitting mosquitoes [24]. These two studies illustrate that the reduction of this nuisance was perceived as more valuable than controlling a disease threat or improving the economy.

The expansion of *Ae. albopictus* has been associated with a decline in native mosquitoes, e.g. *Ae. Triseriatus*, in urban areas of New Jersey and *Ae. aegypti* in Florida and other parts of the southeastern United States [25,26], and a doubling in the share of residents' mosquito complaints due to *Ae. Albopictus* and an overall increase in service requests in New Jersey [1,27]. As part of a comprehensive area-wide integrated pest management project to control *Ae. albopictus* [28,29], this paper describes the experience of Mercer and Monmouth Counties residents' with mosquitoes, quantifies the impact of mosquitoes on their quality of life in terms of utility scores, and estimates the maximum amount they are willing to pay for one additional imaginary work-free and mosquito-free hour spent in yard and porch activities. These results will inform cost-effectiveness and benefit-cost studies when considering the contribution of mosquito control programs in reducing nuisance as well as potential risk of diseases. The findings should help guide public policy to define priority areas and help allocate scarce public resources in the most efficient way to address residents' preferences [9].

## Methods

### Overview

We aimed to quantify the benefits (in monetary value) and effectiveness (in utility value) of an area-wide integrated pest management (AW-IPM) project to control *Ae. albopictus*, implemented in Mercer and Monmouth Counties in New Jersey, from the residents' perspective. The AW-IPM project helped residents to use their yards and porches and enjoy activities there without the nuisance of mosquitoes. We selected three measures for this evaluation. The first was the reduction in the average number of hours lost during a typical summer week engaged in yard and porch activities–eating and cooking in yard or porch, gardening, relaxing and socializing, playing, and maintaining house or care–due to mosquitoes. Annual mailed surveys conducted from 2008 through 2011 in the study sites, with sample sizes ranging from 310 in 2008 to 548 in 2011, allowed us to measure the effectiveness of the AW-IPM project in reducing the number of hours lost per yard and porch activity due to mosquitoes [30]. The second was monetary value of this reduction in hours lost, derived by valuing each hour gained using the contingency valuation method. The third selected measure is the improvement in residents' utility, or satisfaction. We estimated the utility associated with mosquitoes using three methods: (1) the visual analogue scale, (2) a state tradeoff (adapted from the time tradeoff method) that compares experiencing an average day with mosquitoes as they were the summer of 2010 in the respondent's yard and porch with selected health states, and (3) a disease tradeoff based on five diseases with mild disability weights derived from the Global Burden of Disease studies [31]. The utility score range lies between two values: 1 denotes perfect health and 0 denotes deteriorated health status similar to or equal to death, therefore, a higher utility score indicates higher wellness or satisfaction. The utility score will be used to evaluate the effectiveness of the AW-IPM project in improving residents' utility or level of satisfaction, calculate Quality Adjusted Life Years or QALYs gained, and perform a cost-effectiveness analysis.

### Study design

To quantify the hours gained and to measure the utility associated with mosquitoes we selected for potential face-to-face interviews a random sample of 400 households, a subset of the larger mailed household survey conducted in 2010 [28]. The mailed household survey aimed to document the change in the number of hours residents spent engaged in yard and porch activities due to mosquitoes, mosquito-control expenditures, knowledge of mosquito-control measures, and action taken to control mosquitoes, in addition to demographic characteristics [27].

The interviews were conducted between the first week of October and the first week of November 2010, by six trained, two-student teams from the Department of Entomology at Rutgers University: one student interacted with the interviewee, while the other student documented responses and provided visual aid materials when needed. The interviews were conducted between 10am and 8pm, with an average 50 minutes per interview. Three attempts were made to contact each selected household.

### Ethics statement

The investigators sent selected residents a letter a week in advance about the study providing the objectives, approach (interview at their door or home), and contacts for the investigators and Brandeis University Institutional Review Board (IRB) in case of any concerns. The protocol entailed oral consent as the study involved only spoken, private responses to questions that were considered neither risky nor sensitive. Subjects were compensated $10 in appreciation for their time. Consent was documented on study forms by the interviewer's name and date of the interview. The IRB at Brandeis University reviewed and approved the research protocol (IRB number: 09012).

### Approaches to quantify mosquito impact

**Visual analogue scale (VAS) valuation.** To estimate the unpleasantness associated with mosquito abundance, we first used VAS as a rating scale to derive preference weights and create an interval scale [32]. We asked residents to rate the mosquito acceptability during a typical 2010-summer week on a scale from 100 (referring to no mosquitoes–best scenario) to 0 (referring to an invasion of mosquitoes–worst scenario).

**EuroQol states trade-off (EuroQol-STO).** Time-Trade- off (TTO) is a tool used in health economics to determine the quality of life of a patient or group. This tool instructs individuals to choose between living a fixed number of years (usually 10 years or F) in a specified health condition, to living Z years in perfect health. The difference Y, where Y = F–Z, denotes the number of years the respondent is willing to trade to move from living in the specified health condition to living in perfect health. The number of years of perfect health selected (Z) is then converted into a utility score (generally Z/F) and used to calculate QALYs [33].

We modified the TTO method to derive the mosquito-abundance-utility score by allowing residents to elicit preferences between alternative health states, instead of time, and living an average day with mosquitoes. We first asked respondents to remember how it was living an average day with mosquitoes as they were in their yard and porch that summer. We then asked them to select which is a worse state in their opinion: living an average day with mosquitoes as they were in their yard and porch that summer or living in each of five health states selected, as presented in Survey S1. We conceptualized these states as rungs on a ladder, so the respondent could indicate the rung below which their mosquito acceptability fell. These five health states were derived from EuroQol EQ-5D descriptive system, which compromise health dimensions of mobility, self-care, usual activities, pain/discomfort, and anxiety or depression. Each dimension has three levels: no problems, some problems, and extreme problems. These dimensions were analyzed to generate a utility score that ranges between 1 (denoting perfect health) and 0 (equal to death). The five selected health states had utility scores ranging from 0.897 to 0.806, the range that we expected would apply to most respondents [34].

**Disease states trade-off (D-STO).** Using paired comparison questions and population health equivalence, the Global Burden of Disease 2010 study quantified disability weights associated with one year in each specified health condition, where 1 implies a health loss equivalent to death and 0 implies no loss of health or perfect health [31]. These weights, which are the reverse of weights in QALYs, are used to compute the disability-adjusted life-years (DALYs) reported in burden of disease studies. Similar to EuroQol-STO, we selected five diseases with mild disability weights per unit time (shown in parentheses): influenza (0.210), stomach flu (0.281), severe hearing loss (0.032), wrist fracture (0.065), and bronchitis (0.210) [31]. Again, we asked respondents to recall living an average day with mosquitoes as they were in their yard and porch that summer. We then asked them to select which is a better state in their opinion: living an average day with mosquitoes as they were in their yard and porch that summer or living an average day with each of these five health conditions.

**Contingent valuation.** To estimate the benefit associated with a program that reduces mosquitoes' nuisance, we asked respondents to rank five porch and yard activities (i.e., eating and cooking outside, playing, relaxing and socializing, gardening, and maintaining their car or house), and to state the maximum amount they were willing to pay for one additional hour engaged in each of these activities with reduced mosquito nuisance. We started the bid with $1. Four cases (3.3% of our sample) reported extreme values (over $100 per porch or yard activity). We adjusted for these extreme values by winsorizing willingness to pay (WTP) values to the variable's 95th percentiles.

## The survey instrument

To measure the impact of mosquitoes on residents' quality of life we developed a four-section structured questionnaire to complement the mailed survey conducted annually from 2008–2011. The first section focused on interviewee's experience with mosquito bites in their neighborhood during a typical 2010 summer week, whether they were treated for bites, and, if so, the cost of treatment. The second section rated the importance of the ability to relax outdoors without mosquitoes compared to other neighborhood characteristics (1 = not important, 5 = extremely important), and the unpleasantness associated with mosquito bites compared to other unpleasant events that can occur in a typical neighborhood (1 = not unpleasant, 5 = extremely unpleasant). In the third section interviewees were asked to rate and rank the enjoyment associated with five porch and yard activities and to indicate their willingness to pay for one additional imaginary work-free mosquito-free hour each summer week engaged in each of five porch or yard activities. In the fourth section interviewees rated their current mosquito acceptability on a utility scale (similar to EQ-5D-VAS-visual analogue scale) from 100 (no mosquitoes) to 0 (mosquito invasion), and answered the EuroQol-STO and D-STO questions.

## Data analysis

Graduate students from Brandeis University coded the survey responses and entered the data into Excel spreadsheets (Microsoft Corporation, Redmond, WA). Twenty percent of the sample was reentered to check for consistency and quality of the data entry. Data were then transferred to STATA (College Station, TX) for analysis. Results are reported as unweighted means, standard deviations, and standard error of the means for continuous variables and frequencies for categorical variables. Then *t*-tests and Chi-square tests were performed for hypothesis testing.

To estimate each respondent's EuroQol-STO mosquito-abundance utility score, we first coded as 1 those items respondents reported as mosquitoes were worse than the comparison states, and coded items not worse as 0. We then defined a 1-based (worst condition) and 0-based (best condition) utility for each respondent. The 1-based utility was based on items coded as 1;; i.e., those EuroQol descriptive health states for which living an average summer day with the then level of mosquitoes was considered to be worse. The lowest utility of those descriptive states was the 1-based utility score. The 0-based score was the items coded as 0; i.e., the utility of the EuroQol descriptive health state with the highest utility for which the respondent stated that living an average summer day with the then level of mosquitoes was not considered worse.

If mosquitoes were worse than all five EuroQol descriptive health states, we set both the 1-based and 0-based utility scores at 0.806, a value extrapolated downward from the utilities of the five health states above. If mosquitoes were equal to or better than all EuroQol descriptive health states, we set both the 1-based and 0-based utility scores at 0.897, a value extrapolated upward from the utilities of the five states below. Finally, we set each respondent's EuroQol-STO utility as the average of their 0-based and 1-based utilities. For respondents whose answers were consistent with the Euro-Qol ordering of health states, their 0-based and 1-based utilities were identical.

To derive the D-STO utility we used similar categories to those used to derive the EuroQol-STO, with minor modifications. For category 1, we defined a better disease state as the one just better than the mildest of these diseases, which was intellectual disability, mild (disability weight 0.031). For category 2, we defined a worse disease state as the one just worse than the most severe of these diseases, which was neck pain (disability weight 0.286). To help readers interpret the resulting utility values, we identified health states in the Global Burden of Disease Study with comparable utility values [31,35,36].

To validate the WTP results, we estimated a logit model about whether the respondent was willing to pay some finite amount to avoid mosquitoes as a function of household characteristics, exposure to mosquitoes and cost associated with mosquitoes. Additionally, we modeled the positive maximum amount residents were willing to pay for each of the selected yard and porch activities on household characteristics, exposure to mosquitoes, and cost associated with mosquito control and mosquito-related healthcare services using log-linear regression models.

## Results

### Household characteristics

Of the 400 randomly selected addresses, 121 households completed the interview, 58 households were not interested in participating in the study, 9 addresses were not residential units, and 6 addresses were outside the study areas. The remaining 206 households were not successfully contacted. Of the 385 valid addresses, the response rate was 31.4% (121/385), and the cooperation rate was 67.5% (121/(121+58)).

The majority of respondents (55%) were from Monmouth County, women (62%), and in the labor force (57%). Table 1 compares the main characteristics of the study sample with those in the AW-IPM project's selected sites and counties. While some of the variables showed statistically significant differences from the population, the excess of females and larger households is consistent with the study procedures.

### Experience and expenditure associated with mosquito bites

The majority (54.6%) of respondents considered mosquitoes to be a problem, with 30.6% rating mosquitoes as a moderate problem, 12.4% as a severe one, and 11.6% as an extremely horrible one. Mosquitoes prevented 59.5% of respondents from enjoying their outdoor recreational activities, at least to some extent. During a typical summer week, 80.2% of respondents reported being bitten at least once; 77.7% were bitten while outdoors and 23.1% were bitten while indoors. Overall, respondents experienced an average (±standard error of the mean, SEM) of 7.1±1.1 mosquito bites per week. Respondents reported bites at all times of the day or night, including the daytime, when the Asian tiger mosquito bites. The distribution of times was: early morning (11.6%), late morning (11.6%), late afternoon (30.6%), early evening (52.1%), and night (31.4%). These percentages sum to more than 100%, as residents reported being bitten during multiple periods in the day. Of those bitten, 49.6% used existing products at home to treat their bites, 34.7% bought new products, and 4.2% saw a health care provider to treat their bites (1.7% a specialized doctor, and 2.5% a nurse or primary healthcare doctor). For all those interviewed, the average (±SEM) amount paid per person on itching and mosquito bite treatment was $9.14 (±$1.98), on medical providers $9.71 (±9.19), while their insurance coverage paid on average $13.14 (±3.91). The respondents' medical cost associated with relief and treatment of mosquito bites for the study areas during the summer period

**Table 1.** Household characteristics of respondents compared to study sites and counties, 2010.

| Variable | Study sites | Study sample | Sig. |
|---|---|---|---|
| Number of households in county (N = 121)† | | | *** |
| Monmouth | 33% | 55% | |
| Mercer | 67% | 45% | |
| Child at home+ (N = 121) | | | NS |
| Household with one or more people under 18 years | 35% | 37% | |
| Respondent's gender (N = 121) | | | * |
| Female | 51% | 62% | |
| Respondent's age (N = 88) | | | *** |
| 35–44 | 19% | 19% | |
| 45–54 | 19% | 33% | |
| 55–64 | 21% | 27% | |
| 65–74 | 23% | 10% | |
| 75 and up | 18% | 10% | |
| Respondent's level of education# (N = 107) | | | NS |
| Less than 9th grade | 7% | 6% | |
| 9–12 grade | 9% | 7% | |
| High school graduate | 34% | 42% | |
| Some college no degree | 19% | 23% | |
| Associates degree | 8% | 4% | |
| Bachelor degree | 16% | 11% | |
| Graduate or professional | 8% | 7% | |
| Average household size (N = 121) | 2.69 | 3.20 | *** |
| Respondent's employment status (N = 120) | | | *** |
| In the labor force | 60% | 57% | |
| Unemployed looking for a job | 7% | 0% | |
| Not in labor force | 33% | 43% | |

†N denotes the number of respondents to the question.
+child under 18.
#population 25 years and over.
*$p<0.05$;
*** $p<0.001$ based on Chi Squared test (for discrete variables) and t-test (for continuous variables); NS = Not statistically significant.
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(assuming summer is 13 weeks) averaged across all residents, including those with no expenditure, $31.99 (±10.57) per resident, of which 28.5% was paid by households for itching and mosquito bite treatment/products, 30.4% paid by households as co-payment for health consultancies, and 41.1% by insurance companies for medical fees. This distribution shows that multiple sectors were affected financially by mosquito bites. We found no statistically significant difference by gender, except for number of residents who reported being bitten: men were more likely to be bitten compared to women, and women were more likely to use or buy a product to treat bites compared to men. We found no significant difference by county, except for the overall level of rating of the mosquito problem in the neighborhood.

## Importance of mosquito control compared to other public services

Respondents rated the importance of enjoying porch and yard outdoors activities without mosquitoes' nuisance (4.69) second to that of neighborhood safety (4.74) and higher than that of a clean neighborhood (4.58). As shown in Table 2, residents' experiencing 7 mosquito bites in a week was rated as the most unpleasant event (4.71) followed by having trash in their block (4.61), and having mosquitoes outside their residence (4.45).

## Porch and yard activities: importance and willingness to pay

As presented in Table 3, the activity rated as most important was relaxing and socializing in the yard or porch (89.2%), followed by eating and cooking outside (82.7%). The order of these ratings paralleled that of their enjoyment. When asked for the maximum amount respondents were willing to pay for one additional imaginary work-free, mosquito-free hour per summer week engaged in these activities, the ranking of the average maximum amounts they were willing to pay was very similar to the enjoyability ranking. We found one exception in gardening ($7.74), which was ranked fourth but the amount was 6.6% higher than the amount they were willing to pay for playing in the yard ($7.26).

Of those interviewed, 92.4% stated their willingness to pay for this imaginary hour engaged in at least one of these activities: 85.7% were willing to pay at least $0.25 to enjoy eating or cooking outside, 76.5% to play in yard or porch, and 75.6% to enjoy gardening. Eighty-nine percent were willing to pay at least $0.50 to relax and socialize, and 71.4% to maintain their house or car. Table 4 displays determinants of WTP from logit and log-linear regressions.

Willingness to pay any amount was positively associated with residency in Mercer County compared to Monmouth County, having at least one child under the age of 18 years of age, attaining some higher education, being female, being employed full time, being bothered by mosquitoes to the extent that one could not spend the time they desired engaged in yard and porch activities, and incurring some cost associated with mosquito control or health expenditure associated with mosquito bites. Health expenditures associated with mosquito bites showed positive statistically significant impacts on residents' WTP for this additional mosquito free hour (eating $p = 0.051$, playing $p = 0.076$. relaxing $p = 0.051$, maintenance $= 0.018$).

## Loss in utility due to mosquitoes

On average (±SD), residents rated their overall mosquito acceptability score during that summer on a scale of 100 (no mosquitoes) to 0 (mosquito invasion) at 56.74±28.73. Table 5 presents the percentages of respondents' stating that living an average day with mosquitoes in their yard and porch during the summer of 2010 was worse than living an average day with the specified comparator health conditions and diseases. The average (±SD) utility based on EuroQol-STO was 0.87±0.03, corresponding to a utility loss of 0.13. The average (±SD) utility based on the five diseases (D-STO) was 0.79±0.71, corresponding to a disability of 0.21±0.30, which is close to the disability weight attributed to moderate diarrhea (0.202) [31]. We found no significant difference by gender or county.

## Consistency checks

The average (±SD) overall self-rated mosquito acceptability score (using VAS) was significantly lower for respondents with a moderate to severe mosquito acceptability compared with those

**Table 2.** Respondents' perceived importance and unpleasantness of certain aspects of neighborhood, 2010.

| Aspect of living in a neighborhood (N = 121) | Mean | SEM |
|---|---|---|
| Importance of ability to* | | |
| Walk around your neighborhood without seeing garbage or litter | 4.58 | 0.09 |
| Walk in your neighborhood at night without fear of crime | 4.74 | 0.07 |
| Use parks and playgrounds | 4.26 | 0.11 |
| Cross streets in your neighborhood safely | 4.59 | 0.09 |
| Relax, barbecue, play and socialize in your yard or porch without mosquitoes | 4.69 | 0.07 |
| Unpleasantness associated with+ | | |
| Having broken or missing street signs on your block | 3.79 | 0.13 |
| Having trash in your block | 4.61 | 0.08 |
| Seeing graffiti on lamppost or telephone pole on your block | 4.21 | 0.11 |
| Having mosquitoes outside your house | 4.45 | 0.10 |
| Getting seven mosquito bites in a week | 4.71 | 0.07 |

*1 = not important, 5 = extremely important.
+1 = not unpleasant, 5 = extremely unpleasant.
Notation: SEM denotes standard error of the mean.
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**Table 3.** Enjoyment associated with yard and porch activities and willingness to pay (WTP) for one additional work-free, mosquito-free hour per summer week engaged in each of these activities.

| Yard and porch activity | Rate as very important or important | Ranking of activity by enjoyment* | Mean max. WTP | SEM max. WTP |
|---|---|---|---|---|
| Relaxing, socializing, talking, reading, etc. | 89.2% | 1 | $10.75 | 1.39 |
| Eating or cooking outside | 82.7% | 2 | $10.43 | 1.36 |
| Playing catch, Frisbee, bocce, etc. | 64.4% | 3 | $7.26 | 1.04 |
| Gardening | 57.0% | 4 | $7.74 | 1.29 |
| Maintaining house or car | 53.7% | 5 | $6.47 | 1.05 |

* 1 Denotes highest ranked (most enjoyable) activity.
Notation: SEM denotes standard error of the mean.
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who stated mosquitoes as a mild or no problem in their neighborhood (47.67±26.08 and 67.62±28.18, respectively; $t(119) = 4.04$ $p<0.001$). The pattern of the EuroQol-STO utility derived for EQ-5D-3L was similar to that observed for VAS scores; the average (±SD) EuroQol-STO utility was significantly lower for respondents with a moderate to severe mosquito acceptability compared with those who stated mosquitoes as a mild or no problem in their neighborhood (0.86±0.03 and 0.87±0.03, respectively; $t(119) = 2.08$ $p = 0.04$. The two variables are significantly correlated, $r\ (119) = 0.29$, $p<0.01$.

The pattern of the D-STO utility index derived for disability weights was different from that observed in the VAS scores and the EuroQol-STO utility derived from EQ-5D; the average (±SD) indices were significantly higher for respondents with a moderate to severe mosquito experience compared with those who stated mosquitoes to be a mild or no problem in their neighborhood (0.80±0.04 and 0.79±0.02, respectively; $t(118) = -2.39$ $p = 0.02$). We found no correlation between the utility score derived from the EuroQol EQ-5D-3L utility score and the utility obtained from the five disability weights; $\chi^2(65) = 67.63$, $p = 0.39$.

## Discussion

Our study has investigated and explored the impact of mosquito abundance on residents' life in two counties in New Jersey. Our results support observations from previous studies, which indicated the high value residents place on reduction of mosquito nuisance. We also measured the maximum amount they are willing to pay for an active program that can significantly reduce mosquito nuisance and improve the quality of their local environment [7,23,24]. Our results show that on average (±SD) residents were willing to pay the amount of $8.53 (±12.45) per person per week for one additional mosquito-free hour each summer week spent engaged in any yard or porch activity or $9.48 (±13.05) per person per week for an additional recreational mosquito-free hour.

Additionally, our study shows that mosquitoes are a major concern for residents: mosquitoes are forcing them to sacrifice some of the time they would have ideally spent outdoors engaged in yard or porch activities. The high percentage of respondents (80%) being bitten, and the fact that the majority of these bites took place outdoors, resulted in less time spent outdoors. This high rate of respondents' reporting being bitten at least once during a summer week should also be cause for concern about the rapid spread of arboviral diseases, including chikungunya virus, should it ever be introduced in the United States. In Réunion and nearby islands during the 2004–2007 epidemics, much of the population was infected with chikungunya virus within a few months [37].

The mailed survey results show that respondents lost on average (±SEM) 8.43±1.07 hours during a typical 2010 summer week due to mosquitoes, of which 2.42±0.39 hours were lost on average from less eating and cooking outdoors, and 2.81±0.43 hours from less relaxing and socializing. Assuming a constant marginal utility for each additional hour spent outdoors and no budget constraints, our results suggest that residents were willing to pay $71.91±76.94 per person per summer week, or $934.80±1,000.24 per 13-week summer to enjoy their yard activities without mosquitoes.

The negative coefficients associated with the maximum amount residents were willing to pay for one additional imaginary work-free/mosquito-free hour for all activities except relaxing and respondents' education agreed with previous research that found higher education was associated with lower willingness to contribute to mosquito control [38]. Likewise, we found that, on average, more highly educated respondents spent less time in yard and porch activities and had lower WTP. Similarly, the higher WTP in Mercer County is consistent with its 13% lower median household income in 2008–2012 [39,40].

Our study is the first, to our knowledge, to quantify the impact of mosquito abundance and nuisance on residents' quality of life. We used three approaches: the VAS, based on the theory of measurable multi-attribute value function used to order differences in individuals' preferences between alternatives [41], gave an overall self-rated mosquito acceptability status of 56.74. We used EuroQol EQ-5D-3L descriptive system to derive the EuroQol-STO utility score of 0.87, a utility comparable to living with up to two risk factors for diabetes (i.e., abdominal obesity, Body Mass Index of 28 or more, reported cholesterol problems, diagnosis of hypertension, and history of cardiovascular disease) or women experiencing menstrual disorders [35,36]. In the third approach we used the D-STO to derive the mosquito nuisance disability weight of 0.21, comparable to a severe episode of influenza [31].

As expected, the overall scores derived from the EQ-5D-3L, whether measured by VAS or utility index score, were significantly higher in cases where the mosquito experience in the neighborhood was moderate, severe or horrible as stated by respondents, compared to cases where respondents faced no problem or only a mild problem with mosquitoes. However, the D-STO utility scores obtained by comparing the mosquito acceptability that summer with a specified disease were unexpected and disagreed with the results obtained from the EuroQol-STO utility, showing a higher utility score for cases with moderate, severe or horrible mxosquito experience in the neighborhood as stated by respondents compared to those who experienced a mild or no mosquito problem. This might be due to two factors: the first is the low number of respondents who stated that mosquitoes are worse than

**Table 4.** Validation of willingness to pay (WTP).

| Variables | Logit: | Regression on log of positive values of maximum WTP per hour for | | | | |
|---|---|---|---|---|---|---|
| | WTP positive, Exp(B) | Eating | Playing | Relaxing | Gardening | Maintenance |
| Household characteristics | | | | | | |
| Resident of Monmouth county | 0.376 | −0.082 | 0.006 | −0.053 | 0.029 | 0.004 |
| Has one or more children less than 18 | 0.409 | 0.100 | 0.074 | 0.121 | 0.071 | 0.101 |
| Associate degree or higher | 0.055 ** | −0.014 | −0.022 | 0.151 | −0.080 | −0.073 |
| Elderly | 0.482 | −0.022 | −0.066 | −0.056 | 0.079 | −0.039 |
| Female | 0.284 | −0.128 | −0.206 + | −0.184 + | −0.086 | −0.14 |
| Employed full time | 0.811 | 0.187 | 0.155 | 0.043 | 0.167 | −0.009 |
| Number of people living in household | 0.978 | −0.054 | 0.046 | −0.094 | 0.083 | 0.038 |
| Exposure to mosquitoes | | | | | | |
| Hours they would have spent on yard and porch activities | 1.009 | 0.000 | −0.002 | 0.072 | −0.057 | 0.055 |
| Perceived severity of mosquitoes (severe or horrible vs. somewhat or less) | 1.926 | −0.056 | −0.070 | −0.077 | −0.126 | −0.118 |
| Cost associated with mosquitoes ($ during summer) | | | | | | |
| Mosquito control in household | 1.037 | 0.133 | 0.129 | 0.159 | 0.158 | 0.146 |
| Medical expenditures for bites | 1.149 | 0.215 + | 0.208 + | 0.208 + | 0.157 | 0.296 * |
| Model summary | | | | | | |
| Number of observations | 119 | 102 | 91 | 106 | 90 | 85 |
| Log likelihood | 44.158 | | | | | |
| Chi squared | 24.508 * | | | | | |
| Adjusted R-squared | | 0.034 | 0.024 | 0.05 | −0.02 | −0.003 |

+p< 0.1;
* p<0.05;
** p<0.01.
doi:10.1371/journal.pone.0089221.t004

**Table 5.** Percentage of respondents rating an average day with mosquitoes during the summer of 2010 as worse than each comparator condition.

| Comparator | Comparator utility score | Percent* |
|---|---|---|
| EuroQol health state descriptions for EuroQol-STO (n = 121) | | |
| 11211: some problem performing usual activities | 0.888 | 41.32 |
| 21111: some problem walking around | 0.880 | 33.06 |
| 11112: moderately anxious | 0.876 | 26.45 |
| 22111: some problem walking around, and some problem with self-care | 0.823 | 30.58 |
| 12112: some problem with self-care and moderately anxious | 0.815 | 21.49 |
| Disease states for D-STO (n = 120) | | |
| Severe hearing loss | 0.968 | 11.57 |
| Wrist fracture | 0.935 | 14.05 |
| Influenza | 0.790 | 13.22 |
| Bronchitis | 0.790 | 8.26 |
| Stomach Flu | 0.719 | 09.92 |

* As items were independent the percentages could sum to more or less than 100%.

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a disease (average of 11% of respondents) compared to health states (average of 31% of respondents). The second factor is related to the question itself. The results suggest that residents faced difficulties in trading off a day living with mosquitoes to a day living with one of the selected diseases, which are associated with great discomfort and disability and might lead to confinement in bed. However, they were more open and willing to trade-off some moderate states that they can adjust to and live with.

Some limitations of our study must be acknowledged. First, the respondents may have been persons who cared more about mosquitoes than non-respondents. However, the favorable cooperation rate (67.5%), and general similarity on education between respondents and the study sites suggests any potential bias would be limited. Second, the survey assesses reported or intended actions, rather than objectively observed activities. However, the substantial internal consistency (e.g. the same activity–relaxing and socializing–was ranked highest on importance, enjoyability, and WTP) suggested that the responses were thoughtful. Third, to shorten the interviews, we used only selected items from the EQ-5D instead of the full instrument, but may have lost some precision. Fourth, our interviews occurred weeks after the peak biting season, so respondents may not have fully recalled the nuisance they experienced. Fifth, our method analyzed the mosquito nuisance but did not include the potential health threat associated with disease carrying mosquitoes. Incorporating this factor might have increased the utility loss further. Sixth, we presented the unweighted results, since we found no statistically significant differences by county or gender at the customary significance level of $p<0.05$. However, supplementary analysis showed differences between gender groups on the EuroQol-STO utility score at the borderline level of $p = 0.06$. As weighting the results changed only the third decimal place of our results (from 0.871 to 0.873) and lowered precision, we decided to report the unweighted results. Further research could extend this work by applying additional methods, such as a direct utility elicitation technique such as TTO or standard gamble.

Conversely, our investigation also has several strengths. Our sample of 121 cases is adequate to estimate the utility lost due to mosquitoes as it exceeds the suggested minimum of 100 respondents to valuate one condition [42]. To our knowledge, this is the first study to quantify the utility associated with mosquito abundance using three different methods, and it is the first study to put a value on an hour free of mosquitoes spent in yard or porch activities.

The present paper provides evidence of the impact of mosquitoes on residents' quality of life. New Jersey residents report a 0.13 decrement in utility due to mosquitoes, comparable to worrisome health risks. The mosquitoes' nuisance effect is further emphasized by the perceived importance respondents placed on mosquito control activities compared to other public services, such as access to public parks and trash collection.

## Supporting Information

**Survey S1**
(PDF)

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## Author Contributions

Conceived and designed the experiments: DSS YAH. Performed the experiments: DSS YAH DMF AF SH RG KBH DAS GGC. Analyzed the data: DSS YAH. Contributed reagents/materials/analysis tools: DSS YAH. Wrote the paper: DSS YAH DMF AF SH RG KBH DAS GGC.

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# EXHIBIT L

EXHIBIT L

BAY AREA AIR QUALITY
MANAGEMENT DISTRICT

Home | Planning, Rules and Research | CEQA Guidelines

# CEQA Guidelines

UPDATE: January 16, 2014: On June 2, 2010, the Bay Area Air Quality Management District's Board of Directors unanimously adopted thresholds of significance to assist in the review of projects under the California Environmental Quality Act. These Thresholds are designed to establish the level at which the District believed air pollution emissions would cause significant environmental impacts under CEQA and were posted on the Air District's website and included in the Air District's updated CEQA Guidelines (updated May 2012).

On March 5, 2012 the Alameda County Superior Court issued a judgment finding that the Air District had failed to comply with CEQA when it adopted the Thresholds. The court did not determine whether the Thresholds were valid on the merits, but found that the adoption of the Thresholds was a project under CEQA. The court issued a writ of mandate ordering the District to set aside the Thresholds and cease dissemination of them until the Air District had complied with CEQA. The Air District has appealed the Alameda County Superior Court's decision. The Court of Appeal of the State of California, First Appellate District, reversed the trial court's decision. The Court of Appeal's decision was appealed to the California Supreme Court, which granted limited review, and the matter is currently pending there.

In view of the trial court's order which remains in place pending final resolution of the case, the Air District is no longer recommending that the Thresholds be used as a generally applicable measure of a project's significant air quality impacts. Lead agencies will need to determine appropriate air quality thresholds of significance based on substantial evidence in the record. Although lead agencies may rely on the Air District's updated CEQA Guidelines (updated May 2012) for assistance in calculating air pollution emissions, obtaining information regarding the health impacts of air pollutants, and identifying potential mitigation measures, the Air District has been ordered to set aside the Thresholds and is no longer recommending that these Thresholds be used as a general measure of project's significant air quality impacts. Lead agencies may continue to rely on the Air District's 1999 Thresholds of Significance and they may continue to make determinations regarding the significance of an individual project's air quality impacts based on the substantial evidence in the record for that project.

Various tools and resources are available on this website to assist local jurisdictions in applying the Air District's CEQA Guidelines.

For more information, please contact Sigalle Michael, Senior Environmental Planner at smichael@baaqmd.gov or 415-749-4683.

Learn more about the updated CEQA Guidelines.

View the District's 1999 CEQA Guidelines.

To view the State CEQA Guidelines and related materials visit the California Resources Agency.

## California Air Districts Launch Greenhouse Gas Exchange

Update: January 2, 2014

# EXHIBIT M

# EXHIBIT M

**Exhibit M**

I, Andrew B. Sabey, declare as follows:

1. I am a member of the State Bar of California, and I am an attorney with the law firm of Cox, Castle & Nicholson LLP, attorneys for Plaintiff and Respondent California Building Industry Association ("CBIA"). I make this declaration in support of the CBIA's Supplemental Motion for Judicial Notice filed concurrently.

2. I have personal knowledge of the matters set forth in this declaration, and if called upon to testify to those matters, I could and would so testify.

3. Attached hereto as Exhibit H is a true and correct copy of an excerpt of OPR's 2003 General Plan Guidelines from OPR's official website [http://opr.ca.gov/docs/General_Plan_Guidelines_2003.pdf] downloaded on May 27, 2014.

4. Attached hereto as Exhibit I is a true and correct copy of an excerpt of an excerpt of the environmental impact report for the 5th and Colorado Hotel Projects from the City of Santa Monica's official website [http://www.smgov.net/departments/pcd/plans-projects/] downloaded on May 14, 2014.

5. Attached hereto as Exhibit J is a true and correct copy of Yingling Fan, et al., *Is Sprawl Associated with a Widening Urban-Suburban Mortality Gap?*, Journal of Urban Health: Bulletin of the

New York Academy of Medicine, Vol. 86, No. 5, p. 717, 2009 from the U.S. National Library of Medicine National Institutes of Health official website [http://www.ncbi.nlm.nih.gov/pubmed/19533362 ] downloaded on May 15, 2014.

6. Attached hereto as Exhibit K is a true and correct copy of Yara Halasa, et al, *Quantifying the Impact of Mosquitoes on Quality of Life and Enjoyment of Yard and Porch Activities in New Jersey*, PLoS ONE, Volume 9, Issue 3, 2014 from the PLoS One website [http://www.plosone.org/article/fetchObject.action?uri=info%3Adoi%2F10.1371%2Fjournal.pone.0089221&representation=PDF] downloaded on May 15, 2014.

7. Attached hereto as Exhibit L is a true and correct copy of a printout from the District's official website [http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES.aspx] downloaded on May 27, 2014.

I declare under penalty of perjury, under the laws of the State of California, that the foregoing is true and correct.

Executed this 28th day of May 2014 in San Francisco, California.

Andrew B. Sabey

Case No. S213478

IN THE SUPREME COURT OF CALIFORNIA

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**CALIFORNIA BUILDING INDUSTRY ASSOCIATION**
**Plaintiff and Respondent**

**vs.**

**BAY AREA AIR QUALITY MANAGEMENT DISTRICT**
**Defendant and Appellant**

---

**CALIFORNIA BUILDING INDUSTRY ASSOCIATION'S MOTION FOR JUDICIAL NOTICE**

**After a Decision by the Court of Appeal in a Published Opinion**
**First Appellate District, No. A135335 & A136212**

**On Appeal from a Judgment**
**Alameda County Superior Court, No. RG10548693**
**Honorable Frank Roesch, Judge of the Superior Court**

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**[PROPOSED] ORDER**

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The Court grants CBIA's motion and takes judicial notice of the following documents:

Exhibit H _____
Exhibit I _____
Exhibit J _____
Exhibit K _____
Exhibit L _____

IT IS SO ORDERED.

Dated: _______ __, 2014 ________________________________

Justice of the Supreme Court

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PROOF OF SERVICE

I am employed in the County of San Francisco, State of California. I am over the age of 18 and not a party to the within action; my business address is 555 California Street, 10th Floor, San Francisco, California 94104-1513.

On **May 28, 2014**, I served the foregoing document(s) described as

**CALIFORNIA BUILDING INDUSTRY ASSOCIATION'S SUPPLEMENTAL MOTION FOR JUDICIAL NOTICE; DECLARATION OF ANDREW B. SABEY & [PROPOSED] ORDER**

on ALL INTERESTED PARTIES in this action by placing a true copy thereof enclosed in a sealed envelope addressed as follows:

**Please see attached Service List**

On the above date:

_x_ BY U.S. MAIL The sealed envelope with postage thereon fully prepaid was placed for collection and mailing following ordinary business practices. I am aware that on motion of the party served, service is presumed invalid if the postage cancellation date or postage meter date on the envelope is more than one day after the date of deposit for mailing set forth in this declaration. I am readily familiar with Cox, Castle & Nicholson LLP's practice for collection and processing of documents for mailing with the United States Postal Service and that the documents are deposited with the United States Postal Service the same day as the day of collection in the ordinary course of business.

I hereby certify that the above document was printed on recycled paper.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on **May 28, 2014**, at San Francisco, California.

Michell Ho

**SERVICE LIST**
Supreme Court of California Case No. S213478

*CALIFORNIA BUILDING INDUSTRY ASSOCIATION, et al. v.*
*BAY AREA QUALITY MANAGEMENT DISTRICT*
APPELLATE CASE NOS. A135335 & A136212

| Party | Attorney |
|---|---|
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| Alameda County Superior Court<br>Case No. RG10-548693 | The Honorable Frank Roesch<br>Alameda County Superior Court<br>1221 Oak Street<br>Oakland, CA 94612 |
| Court of Appeal of the State of California<br>First Appellate District, Div. 5,<br>Appellate Case Nos. A135335 & A136212 | Clerk of the Court<br>Court of Appeal of the State of California<br>First Appellate District, Division 5<br>350 McAllister Street<br>San Francisco, CA 94102-3600<br>Tel: 415-865-7300 |
| | VIA HAND DELIVERY<br><br>Clerk of the Supreme Court<br>Supreme Court of California<br>350 McAllister Street<br>San Francisco, CA 94102-4797<br>Tel: 415-865-7000<br>(Original and 9 copies) |

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|---|---|
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