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At The Microscale: Compact Growth and Adverse Health Impacts

Gail M. Sandlin
University of Washington

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Informational Paper on
"Compact Growth and Adverse Health Impacts"

This paper was developed by University of Washington Doctoral Student Gail Sandlin under a contract with the Puget Sound Regional Council. The scope of the contract contained the following primary tasks:

- Provide information and perspective on the topic of “Compact Growth and Adverse Health Impacts”
- Discuss the key findings from a literature review regarding the adverse health impacts of compact city design.
- Discuss possible mitigation measures that might be appropriate as part of the analysis of alternatives and potential mitigation measures in the VISION 2020+20 environmental impact statement process.

The purpose of the paper is to provide information to support the Environmental Impact Statement process for Vision 2020+20. The paper is meant to provide Puget Sound Regional Council a literature review on the environmental (adverse health) impacts of the compact city design. The final report summarizes some the major articles/reports on the topic, and includes a set of key findings. The paper provides a brief discussion of applicability to various growth scenarios and possible mitigation measures.

Purpose

To advance a broader understanding of (1) the potential adverse health impacts of compact city design on vulnerable populations, and (2) the relationship of traffic, air quality and land use patterns within the micro or local scale of compact urbanization. This paper is meant to improve the understanding of these issues as part of the update of VISION 2020 + 20.

Introduction

The Washington State Growth Management Act is designed to protect the natural environment by such initiatives as controlling sprawl through regional countywide and local comprehensive plans. The antithesis of sprawl is compact growth that promotes active living by encouraging physical exercise through mobility - either walking or bicycling - in a pedestrian-friendly urban environment. Looking towards the future within its VISION 2020+20 update the Puget Sound Regional Council (PSRC) proposes, for environmental assessment, four growth alternatives where population and employment increases are distributed throughout the various regional geographies categorized as metropolitan cities, core suburban cities, larger suburban cities, smaller suburban cities, unincorporated UGA or rural areas. The targeted growth areas of many of these regional geographies are transected by urban freeways thus creating at the microscale or local level a nexus of land use, transportation and air quality; in other words, the potential for localized air pollution impacts on populations living or attending schools within close proximity to high volume traffic.

As reported in the recent *Issue Paper on Environmental Planning* this scenario of air quality “hot spots” from heavy traffic is recognized by PSRC as an emerging issue (PSRC 2005c p 8, 13, 32). To advance a broader understanding of the potential adverse health impacts of compact growth for consideration in the environmental impact analysis of project VISION 2020 + 20, this paper examines this relationship of traffic, localized air quality and land use patterns. Section one of this paper will provide a synopsis of recent reports, studies and academic literature on localized air quality as a consequence of compact urbanization within developed countries, not as an admonition of compact growth but rather to increase awareness amongst planners and policy makers. Section two will include a summary of the potential adverse health impacts as reported in recent scientific studies and reviews. The third section will briefly discuss mitigation strategies with the paper concluding by posing questions for future research.

Within the context of this paper, it is important to define several terms, particularly (a) *vulnerable populations*, (b) *adverse health impacts*, (c) *compact growth*, and (d) *density*.

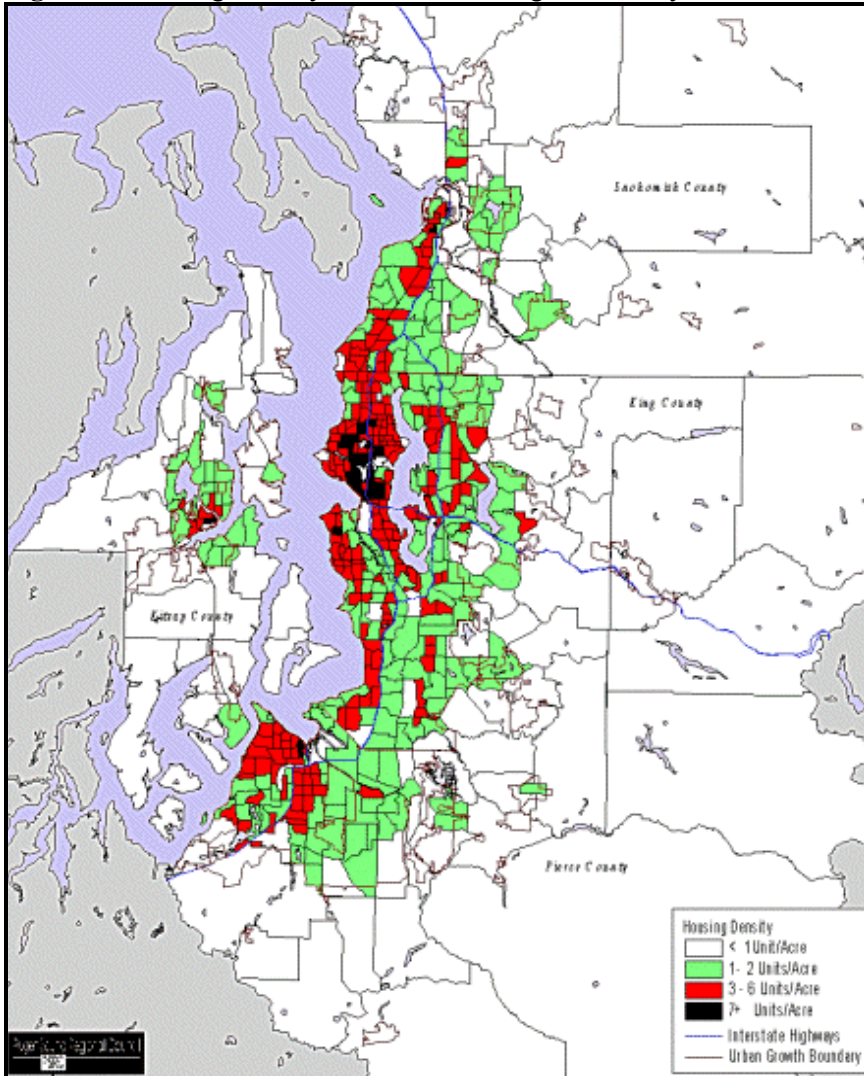
(a) *Vulnerable populations* include populations that have an increased sensitivity to environmental pollutants, typically children, the elderly and those with pre-existing health conditions such as cardiovascular or respiratory disease (American Academy of Pediatrics 2004; California Air Resources Board 2005). In addition, there is an increasing body of research that suggests that low income / minority populations within the urban environment may also be more vulnerable to the impact of environmental burdens (Gwynn and Thurston 2001; Houston et al. 2004). This may be the consequence of proximity relationships i.e. poverty and poor environmental quality or other confounding factors such as poor quality housing, inadequate nutrition or limited access to health care.

(b) *Adverse health impacts*, for the purposes of this discussion paper, refers to the range of health effects that may occur as a result of exposure of vulnerable populations to environmental pollutants, especially pollutants from high volume traffic sources, see Section 2.

(c) *Compact growth* includes both compact urban centers and communities. Although there a range of variables to define compact growth, for the VISION 2020 + 20 update, the compact urban form is a function of population/employment density that includes pedestrian oriented design scale and transportation modes.

(d) *urban density*. There are a variety of methodologies to estimate urban density, the most common are housing density, as residential units-per- acre; and population density, as persons-per-acre. According to the Central Puget Sound Growth Management Hearings Board (GMHB) an urban density has been defined as four (4) units/net developable acre, although less density may be appropriate in areas with large environmentally sensitive systems (CPSGMHB 2004 p 402).¹ By color-coding the housing units per acre, Figure 1 illustrates the 1999 Central Puget Sound's regional housing densities for each census tract.² Population density is then determined by utilizing a *housing unit measure* calculated as the number of occupied housing units in a census tract's housing stock multiplied by the tract's average household size (PSRC 1999).³

Figure 1: Housing Density in the Central Puget Sound by Census Tract: 1999



<http://www.psrc.org/datapubs/pubs/pophsg99-fig21.htm>

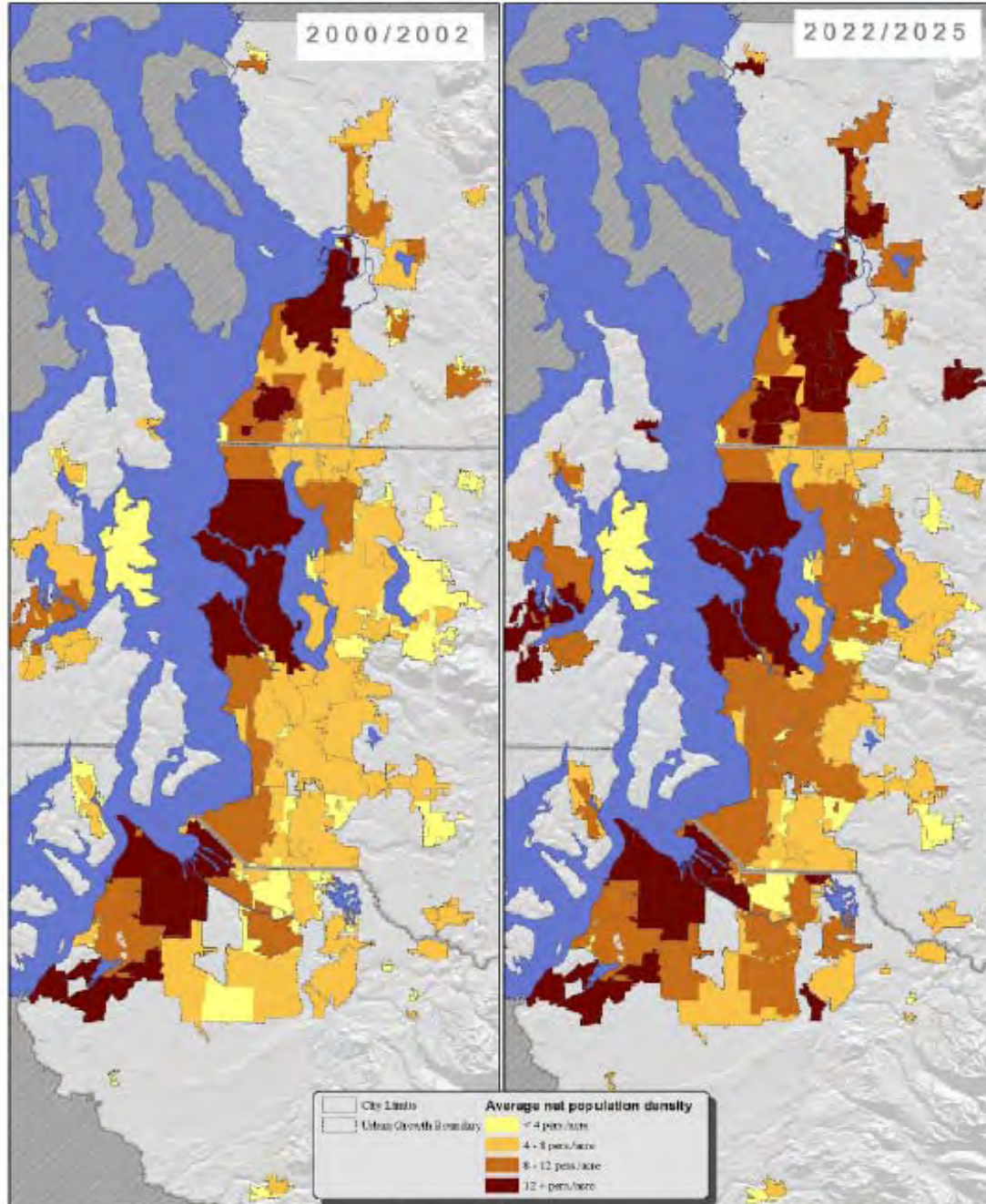
¹ Gross density = total residential units / total development land area (acres) ; Net density = total residential units / total residential land area (excludes roads and other areas)

² It is important to note that the population estimates were calibrated from the 1990 Census data to match Washington State Office of Financial Management's April 1, 1999 population estimates (OFM 1999).

³ As a reference comparison, 1 person per acre is equivalent to 640 persons / square mile

The region's counties use different methodologies for establishing growth targets, however, the Regional Council, as a multicounty planning agency compared the growth targets in its 2005 *Growth Management by Numbers* paper (PSRC 2005b). An example of the results are illustrated in Figure 2 that maps the adopted growth targets of regional cities as a function of average net population density per acre. In addition, Regional Council guidance policies emphasize that the "strategy is to contain much of the region's projected growth within defined urban growth areas, creating compact urban communities" (PSRC 1995).

Figure 2: Regional Growth Targets: Twenty Year Net Population Density Change



<http://www.psrc.org/projects/monitoring/growthtargets/growthtargets.pdf>

Background of Vision 2020+20 update

The four regional growth alternatives of the VISION 2020 + 20 update distribute future growth patterns amongst a set of regional geographies – this data is provided in Table 1. The data in the lower section of Table 1 provides the total estimates for residential and employment populations⁴ in the various regional geographies in 2040 (as well as the percent distributions), whereas, the data in the top section of the table estimates the residential and employment population increases in 2040 from the year 2000 baseline, also including the percent distributions amongst the regional geographies.

Table 1: Regional Growth Alternatives - Percent Distribution of Growth to the year 2040

VISION 2020+20 Update - Alternatives Data Summary						
Amount of Change	Metropolitan Cities	Core Suburban Cities	Larger Suburban Cities	Smaller Suburban Cities	Uninc. UGA	Rural Area
Alternative #1: No Action	25%	15%	10%	10%	25%	15%
Population	482,637	292,874	150,528	199,482	401,776	244,447
Employment	432,675	312,694	77,781	192,387	107,238	93,461
Alternative #2: Metropolitan Cities	40%	25%	15%	10%	5%	5%
Population	706,916	441,822	265,093	176,729	88,364	88,364
Employment	486,494	304,059	182,435	121,624	60,812	60,812
Alternative #3: Larger Cities	20%	30%	30%	5%	10%	5%
Population	353,458	530,187	530,187	88,364	176,729	88,364
Employment	243,247	364,871	364,871	60,812	121,624	60,812
Alternative #4: Smaller Cities	10%	10%	5%	30%	35%	10%
Population	176,729	176,729	88,364	530,187	618,551	176,729
Employment	121,624	121,624	60,812	364,871	425,683	121,624
End State Figures						
Base Year 2000						
% Population	30%	18%	10%	8%	19%	15%
Population	959,653	578,410	332,581	254,397	622,292	473,378
% Employment	50%	27%	6%	6%	7%	4%
Employment	909,931	502,377	115,940	103,423	122,060	77,333
Alternative #1: No Action						
% Population	29%	17%	10%	9%	20%	14%
Population	1,442,290	871,284	483,109	454,065	1,019,427	717,825
% Employment	44%	27%	6%	10%	8%	6%
Employment	1,342,606	815,071	193,721	295,810	229,298	170,794
Alternative #2: Metropolitan Cities						
% Population	33%	20%	12%	9%	14%	11%
Population	1,666,569	1,020,232	597,674	431,126	710,657	561,742
% Employment	46%	26%	10%	7%	6%	5%
Employment	1,396,425	806,436	298,375	225,047	182,872	138,145
Alternative #3: Larger Cities						
% Population	26%	22%	17%	7%	16%	11%
Population	1,313,111	1,108,597	862,768	342,761	799,021	561,742
% Employment	38%	28%	16%	5%	8%	5%
Employment	1,153,178	867,248	480,811	164,235	243,684	138,145
Alternative #4: Smaller Cities						
% Population	23%	15%	8%	16%	25%	13%
Population	1,136,382	755,139	420,945	784,584	1,240,844	650,106
% Employment	34%	20%	6%	15%	18%	7%
Employment	1,031,555	624,001	176,752	468,294	547,743	198,957

Source: PSRC, 2005

⁴ With the VISION 2020+20 project, the concept of *activity unit* is introduced that combines residential and employment populations as a measure of density per acre.

To summarize the alternative growth patterns:

- Alternative #1 – This *no action* growth alternative continues to concentrate populations in metropolitan cities, the unincorporated UGA, and the rural area.
- Alternative #2- The *metropolitan cities* growth alternative shifts populations away from unincorporated UGA to the metropolitan and core suburban cities.
- Alternative #3- The *larger cities* growth alternative shifts populations to core suburban and larger suburban cities.
- Alternative #4 - The *smaller cities* growth alternative concentrates populations in smaller suburban cities and in the unincorporated UGA.

Cities located within the regional geographic categories are listed in Table 2 and what is interesting to note, urban freeways transect or border the targeted growth areas of many of these cities as illustrated either in the city’s planning web site or the 2002 PSRC report *Regional Growth Centers – Characteristics and Comparisons* (PSRC 2002).

Table 2: Cities within Regional Geographies

Note: Italicized and boldfaced cities: urban freeways transect or border targeted growth areas

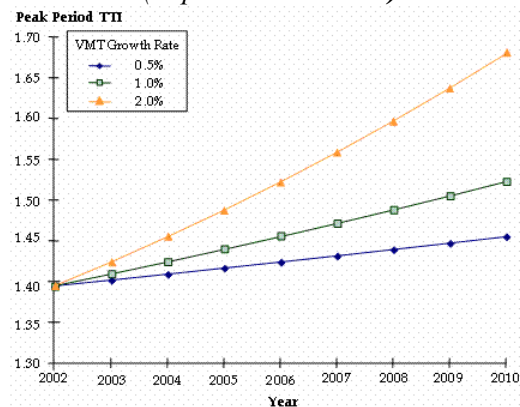
Metropolitan Cities	Core Suburban Cities	Larger Suburban Cities	Smaller Suburban Cities
<i>Bellevue</i> , Bremerton, <i>Everett</i> , <i>Seattle</i> , <i>Tacoma</i>	Auburn, <i>Bothell</i> , Burien, <i>Federal Way</i> , Kent, <i>Kirkland</i> , <i>Lakewood</i> , <i>Lynnwood</i> , Puyallup, Redmond, <i>Renton</i> , <i>SeaTac</i> , Silverdale, <i>Tukwila</i>	Bainbridge Island, Des Moines, Edmonds, <i>Issaquah</i> , Kenmore, <i>Marysville</i> , Mercer Island, <i>Mountlake</i> <i>Terrace</i> , Mukilteo, Sammamish, <i>Shoreline</i> , University Place, <i>Woodinville</i>	Type A: Smaller Cities and Towns (inside Contiguous UGA): <i>Algona</i> , Arlington, Black Diamond, Bonney Lake, Brier, Covington, DuPont, Edgewood, <i>Fife</i> , Fircrest, Gig Harbor, Lake Forest Park, Lake Stevens, Maple Valley, Medina, Mill Creek, Milton, Newcastle, Normandy Park, Orting, <i>Pacific</i> , Port Orchard, Poulsbo, Ruston, Steilacoom, Sumner. Type B: Small Residential Towns (inside Contiguous UGA): Beaux Arts, Clyde Hill, Hunts Point, Woodway, Yarrow Point. Type C: Free-Standing Cities and Towns: Buckley, Carbonado, Carnation, Darrington, Duvall, Eatonville, Enumclaw, Gold Bar, Granite Falls, Index, Monroe, North Bend, Roy, Skykomish, Snohomish, Snoqualmie, South Prairie, Stanwood, Sultan, Wilkeson.

Discussion of Compact Growth and Transportation

In 2002, the Center of Disease Control in Atlanta, Georgia sponsored a workshop attended by an interdisciplinary scientists to explore a research agenda that might be associated with the influence of community design on air pollutant emissions and consequently adverse health effects (Dannenberg et al. 2003). One question posited, “What tradeoffs in terms of criteria air pollutants, particulate matter, and air-borne toxics are involved with land-use policies that promote increased density, walkability, and connectivity? For example, although higher density may reduce per capita vehicle emissions on a regional basis, it may create more traffic congestion and higher levels of different pollutants in dense areas” (Dannenberg et al. 2003 p 1504). In other words, emissions output may be highly concentrated in high-density cities which may lead to more concentrated impacts and higher exposure (Frank and Engelke 2005; Kenworthy and Laube 2002). It should also be pointed out that these authors are not advocating dispersal and sprawl but rather attention paid to the relationship of traffic emissions and population density at the local level.

This brings us to the issue of the impact on land use policies that seek to address automobile use. An literature review by Badoe and Miller examined the empirical findings that investigated a range of variables on the transportation-land-use interaction such as residential density, employment density, accessibility, neighborhood design, automobile ownership, socioeconomics and transit supply (Badoe and Miller 2000). The authors concluded that the collective research yields mixed results on the influence of urban form on travel. To add to the debate, according to the study by Kitamura et al. attitudes are more strongly associated with travel than are land use characteristics with the authors suggesting that policies that promote higher densities may not alter travel demand (Kitamura et al. 1997). The important issue here is that compact urban growth centers may not be void of traffic, especially considering the proximity of urban freeways to many of the cities within the PSRC regional geographic categories. In addition, the movement of goods and services will still require commercial fleets, which may release ultrafines, diesel particulates and toxic air pollutants within the microscale pedestrian environment and within proximity to urban freeways.

Graph 1. Projected Growth in Urban Freeway Congestion under Different VMT Growth Rates, 2002-2010 (Top 78 Metro Areas)



Notes:

- The Travel Time Index (TTI) is a measure of total congestion. It is the ratio of the peak-period travel time to the travel time under ideal conditions. A TTI value of 1.4 indicates that peak-period travel takes 40 percent longer than under ideal conditions
- Specific congestion data for Seattle: http://mobility.tamu.edu/ums/congestion_data/tables/seattle.pdf

Furthermore, the August 2005 *Puget Sound Trends* report states that “that automobile travel in the central Puget Sound region has grown at the same rate as population and employment” (PSRC 2005a). The report also states that “If the construction of new roads simply keeps pace with this growth, then congestion at current levels or worse may continue into the foreseeable future” (PSRC 2005a).

The Federal Highway Administration also examined the effect of different vmt growth rates on urban freeway congestion. As presented Graph 1, a 2% increase in vmt has a significant impact on travel time index (TTI) as a measure of congestion (Cambridge Systematics 2004). The important point is not to debate whether construction of roads

is a solution to traffic congestion but to point out that 1) increasing vehicle miles traveled (vmt) may result in increasing congestion and 2) congestion alleviation may result in freeway expansion projects. Specific local freeway expansion projects can be viewed at Washington State Department of Transportation's web site (WSDOT 2005). If given that both freeway congestion and expansion exist regionally, then the issue to explore with respect to adverse health impacts (see Section 2) is whether populations are living or attending schools within proximity to congested freeways. Within the context of the regional growth alternatives, if densification occurs, does this also encourage infill? With respect to population proximity to high volume traffic, can infill create a "coming to the nuisance" or alternatively, with freeway expansion is the nuisance coming to populations and who are these populations?

Section 1. The Microscale or Local Environment

In 2004, a session of the annual conference sponsored by the Health Effects Institute was based on the "emerging evidence [that] suggests that air pollution gradients within cities and associated health effects may be larger than previously appreciated" (Tager 2004 p 5). The importance of this is that both regional and local air quality should be considered when determining pollution impacts from motor vehicles. Although aggregation is a standard methodology, the consideration air quality impacts within the growth centers of the regional alternatives is perhaps of equal importance. After all, is it not the local where that sense of place, of community and the pedestrian-oriented environment exists? The following studies, research reports and legal rulings may provide both insight into microscale air quality impacts within urban communities and perhaps guidance for future assessments of PSRC's growth alternatives.

a) Localized Air Quality Impacts

Considering that many traffic pollutants disperse from the roadside edge at an exponentially decreasing concentration, the obvious question may be to investigate whether populations reside or attend schools within this microscale environment. European researchers have been doing just that. Although the European compact city is often referenced as a pedestrian-oriented urban growth model, the following studies suggests that the relationship between compact living and motorized traffic presents potential adverse health conditions. As stated by Dutch environmental epidemiologist Bert Brunekreef "society is witnessing a transition from classical pollution, dominated by SO₂ and particles generated by coal and oil combustion ... to pollution mixtures dominated by traffic exhausts" (Brunekreef and Sunyer 2003). It should also be noted that within Washington State, the primary source of air pollutants is motor vehicles (American Lung Association of Washington 2005; Puget Sound Clean Air Agency 2003; Washington State Department of Ecology 2005).

In the Puget Sound region, carbon monoxide is often monitored at busy intersections, however, air quality monitors are rarely sited within 100 m of urban freeways with the exception of a CO monitor near Interstate 5 at 5th and James St, Seattle⁵ and a recently sited particulate black carbon monitor at 20 meters from the freeway edge of Interstate 5 at Olive Street, Seattle (Gilroy et al. 2004; PSCAA 2005). Black carbon is a surrogate for diesel particulate matter and mobile sources, especially diesel engines, are a major source of black carbon. Exactly what the black carbon levels are at increasing distances from the freeway is currently not measured but given that populations both live and attend schools within 100 m to urban freeways, this information would be important. Also, within planning practice the interdisciplinary bridge to

⁵ Monitoring ended February 28, 2001

environmental health may not be adequately understood, yet there may be significant environmental health consequences of planning actions.

Figure 3. Highway A13 - Rotterdam-Overschie



Netherlands

There have been numerous environmental health studies on the adverse health effects from residential or school proximity to major traffic sources in urbanized areas of the Netherlands; Figure 3 (Brunekreef et al. 1997; Janssen et al. 2003; Roorda-Knape et al. 1998; van Vliet 1997). These studies examined the respiratory health of children either residing or attending a school within 300 meters of roadways that had an average of 70-150 thousand vehicles per day. Various traffic pollutants such as PM₁₀, PM_{2.5}, black smoke, NO₂ and benzene were monitored at various distances from these roadways. The most prevalent impacts on respiratory health were observed within 100 meters of the traffic sources. Unlike similar studies within the United States, these studies did not investigate the socio-economic status (SES) of populations in their study area with the exception of van Vliet et al. This research group found that even after controlling for SES confounding factors, that “the associations between traffic related air pollution and respiratory health was mainly to children of intermediate to low SES” (van Vliet 1997).

Figure 4: Oxford Street, London U.K.



United Kingdom

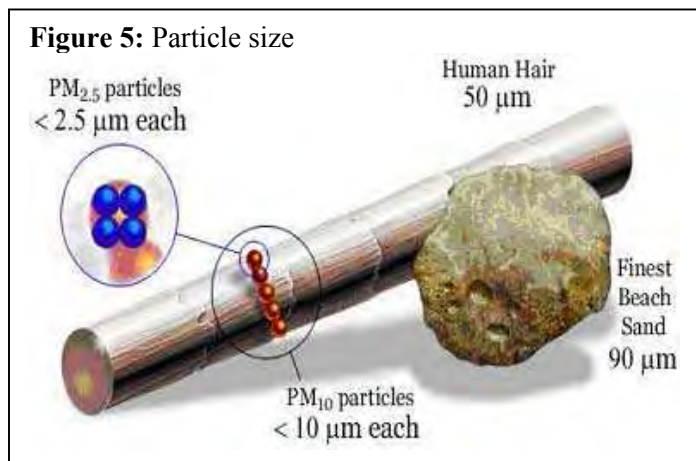
Research studies investigating the adverse health impact on populations that live within proximity to busy roads have also been conducted in the United Kingdom (Edwards and Walters 1994; Venn et al. 2001; Zhang et al. 2003). The Zhang study is most intriguing since it utilizes what the researchers describe as “a natural exposure chamber – that is, a street in London (Oxford Street) with almost exclusively diesel-vehicle traffic” to test the hypothesis whether diesel exhaust leads to a worsening of asthma symptoms and reduced lung function, Figure 4 (Zhang et al. 2003 p 7). Measured concentrations of elemental carbon, a surrogate

for diesel, was found to be five times greater at Oxford St. than the concentration at the control area – Hyde Park. Another recent study from the British Heart Foundation reported that urban cyclists may also be at increased risk of heart disease from exposure to bus diesel exhaust (Templeton 2005).

Japan

Modern, motorized and very dense urban areas in Japan, despite the existence of sophisticated subways systems, have felt the impact of traffic on local air quality. An early study examined the adverse health impact of traffic emissions on adult females living within 20 meters of major

roadways in the suburbs of Tokyo (Nitta et al. 1993). As researchers continued to reveal a link between particulate matter and asthma, the courts responded with a ruling that, “the Japanese government as the road administrator must pay compensation to plaintiffs in Amagasaki who lived in or commuted to the area within 50 meters from Route 43 when they contracted asthma”(Kanemoto et al. 2001 p 2). In response, the Environmental Ministry of Japan recently announced initiation of a five year survey to investigate the causal relationship between traffic pollution and asthma in children (The Japan Times 2004). This study will focus on approximately 16,000 elementary schoolchildren at 60 various schools in major cities where the schools are located within proximity to traffic sources that exceed 40,000 vehicles per day. Controls for this study include elementary school children attending schools not within proximity to traffic or in rural areas.



Australia

An emerging area of research with respect to traffic emissions is the release of ultrafine particles, which are less than 0.1 micron size, in other words, particles so small that their total mass is insignificant when compared to PM₁₀ or PM_{2.5}. Figure 5 illustrates the size of PM_{2.5}, in comparison to human hair and ultrafines are 25x smaller than PM_{2.5}. According to Australian researchers, in an urban environment over 80% of particle

matter in terms of *number* is related to ultrafine particles (Morawska et al. 1998). It is important to note that due to the complex surface areas of ultrafines that “particle toxicity may be more closely related to the surface area of the particles than to their mass” (Bates and Caton 2002 p 113.) A study of major roadways in Brisbane, Australia concluded that exposure to ultrafine particles is significantly increased within distances up to 150 m from the edge of major roadways as compared to urban average exposure levels so that “it is reasonable to assume that personnel living and working in close proximity to an urban freeway will likely be exposed” (Hitchins et al. 2000 p 59). Significant research on ultrafines has also been conducted in the U.S. as discussed in the next section.

United States

Within the United States, there is a growing body of research on the adverse health effects from proximity to traffic emissions, however, this section will discuss only a few of the recent studies which have influenced policy initiatives and legal settlements. Researchers from the University of California Los Angeles measured ultrafine particles at various distances downwind from a nine lane freeway with a traffic volume of approximately 300,000 vehicles per day (Zhu et al. 2002). Within 100 m of the freeway edge the concentrations of ultrafines were 25x higher than background, with the researchers concluding, similar to the Australian study, that “people who live, work or travel within 100 m downwind of major traffic sources will have much higher ultrafine exposure than those who live further from such sources” (Zhu et al. 2002 p 1032).

Of course, the potential adverse health impacts of proximity to traffic prompts the question, “who lives next to major traffic sources and are they vulnerable?” This was the focus of two important California studies (Green 2004; Gunier et al. 2003). The statewide Gunier study found that low-income and minority children were three times more likely to live in high traffic areas than white children. The study by Green et al. found that a higher percentage of minority

and low income schools were located near high traffic roads. The environmental justice implications were influential in having Senator Escutia of District 30 of Los Angeles County introduce Senate Bill 352 (California Senate 2003). This approved Bill, referencing data from both studies, amended Section 17213 of the Education Code restricting the siting of a new school within 500 feet from the closest traffic lane of a freeway or busy traffic corridor.

Recently the California Air Resources Board issued a guidance document, citing Senate Bill 352 and previous research on the potential health impacts associated with proximity to air pollution sources, which included freeways and high traffic sources as risk factors (California Air Resources Board 2005). This document characterizes both sensitive populations and land uses. The former is described as “segments of the population most susceptible to poor air quality (i.e. children, the elderly and those with pre-existing serious health problems affected by air quality).” (California Air Resources Board 2005 p 2). Sensitive land uses are described as residences, schools, day care centers, playgrounds and medical facilities. The recommendations are only advisory in nature and the guidance document does not address the topic of what to do about existing facilities. Nevertheless, the *Air Quality and Land Use Handbook: A Community Health Perspective* is a useful educational tool for planners concerned about the nexus between traffic, land use and local air quality impacts.



A recent court settlement agreement may bring salient an understanding of local air quality impacts of traffic sources or perhaps facilitate a universalized policy (U.S. District Court 2005). The Sierra Club had filed suit regarding the initial Environmental Impact Statement for a 4-lane expansion of US 95 in Las Vegas, Nevada, claiming that it did not sufficiently address local air quality impacts on local residents. In December 2004, the American Academy of Pediatrics published its policy statement on ambient air pollution and health hazards to children by summarizing the recent literature and listing recommended action items. The literature review included the impact of traffic related pollutants on children’s health with the Academy recommending the "siting of school and child care facilities should include consideration of

proximity to roads with heavy traffic" (American Academy of Pediatrics 2004). The position of the American Academy of Pediatrics and the large body of scientific evidence connecting traffic pollutants to adverse health effects in children were influential in the terms of a settlement agreement, ending a ten year legal battle(Sierra Club 2005).

In return for Sierra Club withdrawing its challenge to the U.S. 95 project, the Nevada Department of Transportation and the Federal Highway Administration will conduct air quality monitoring at three elementary schools that will be located within 100 m of a freeway with a volume of 300,00 vehicles per day as a result of the expansion project, see Figure 6. In addition, five major highways across the country will be selected for local air quality monitoring to determine the level and behavior of diesel particulates and diesel organic gases. With respect to this settlement agreement, the policy position of the American Academy of Pediatrics, and the California’s legislation regarding school siting near freeways, the Executive Director of the Association of Local Air Pollution Control Officials states “ I predict that within a couple or three years you’ll see the same kinds of ordinances almost everywhere” (Young 2005).

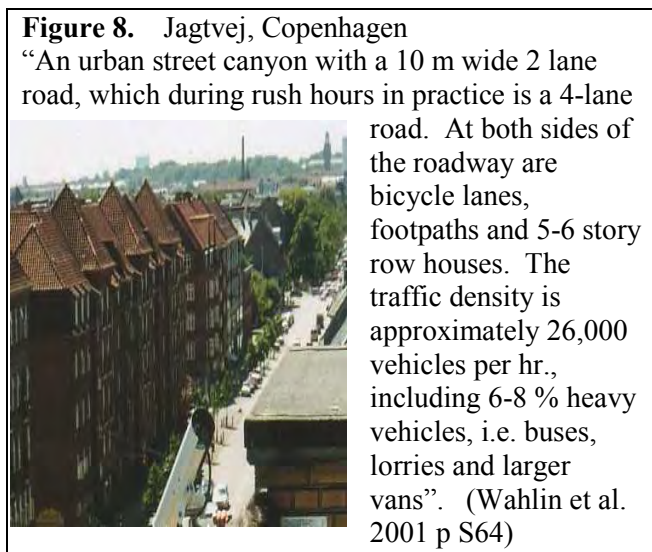
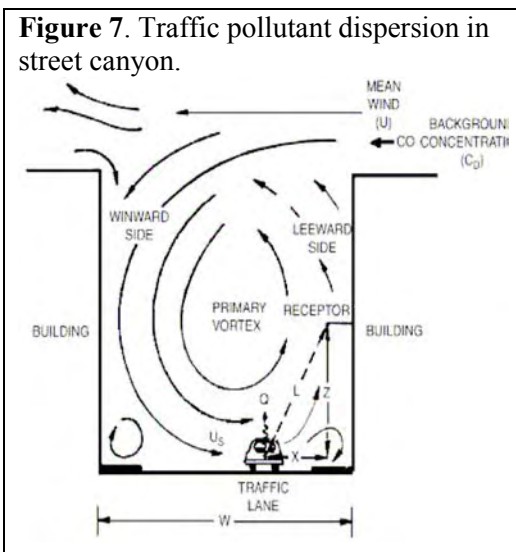
In the Puget Sound region, Professor Christine Bae and doctoral students from the Department of Urban Design and Planning at the University of Washington are conducting

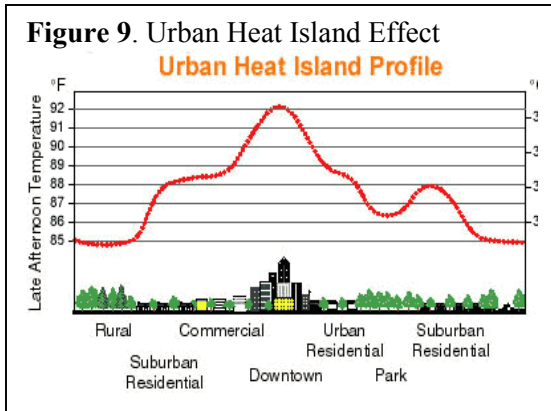
research on spatial land use patterns within proximity to urban freeways. The preliminary findings of the UW research team indicate that retirement homes, multifamily residential complexes, day care facilities and public / private schools are located within 100 m of the freeway edge. Although private school data is not readily available, the researchers found that public schools located within 100 m of urban freeways are attended by predominately low-income and minority students. The findings suggest that existing land use patterns within proximity to urban freeways may already place vulnerable populations at risk to exposure to motor vehicle pollution from high volume traffic.

b) Emerging Issues of Compact Growth

Urban canyons

Urban canyons, described as urban streets flanked by buildings on both sides, may also have concentrations of high traffic pollutants as illustrated in Figure 7 (Vardoulakis et al. 2003). A Danish study also found that there was significant correlation in the average weekly cyclic patterns of NO_x , CO and ultrafine particle concentrations detected in an urban street canyon, indicating that traffic was their major source, Figure 8 (Wahlin et al. 2000). Modeling urban street canyon pollutants is somewhat complex, for example, in a test exercise, 24 modellers used a range of models to predict pollutant concentrations in the same street canyon with large discrepancies between the various model predictions (Vardoulakis et al. 2003). It is also rare for regulatory air monitoring to occur in urban canyons due to temporal variations caused by changing wind, temperature and traffic conditions. Nevertheless, urban canyons in compact urban areas may be a potential source of pedestrian and building occupant exposure to traffic pollutants. If we look forty years into the future, strategies for densification such as increasing building heights may require us to pay closer attention to the issue of urban canyons within the Puget Sound region's growth centers.





Urban Heat Island

Urban areas with heat absorbing materials such as metal, asphalt and concrete maintain higher temperatures than the surrounding countryside. As illustrated in Figure 9, this disparity in regional ambient temperature is described as the urban heat island (UHI) (Ote 1995). The heat island effect is one factor among several that can raise summertime temperatures to levels that pose a threat to public health (U.S. EPA 2005a).

According to the CDC, exposure to excessive heat can cause illness, injury and

death, with the elderly, the very young, and people with chronic health problems most at risk (Center of Disease Control 2005). After 60 heat-related fatalities in 1992, Seattle became a participating city in the heat-health warning system (U.S. EPA 2005b).

Noise

Another environmental health problem with respect to traffic is its contribution to urban noise, impacting large segments of the urban population who live within proximity to freeways, busy highways and streets (Sanford 1977; U.S. DOT 2000; World Health Organization 1999). The *Guidelines for Community Noise* published by the World Health Organization states that populations vulnerable to the adverse health effects of noise include children and the elderly (World Health Organization 1999). According to the Federal Highway Administration for populations living within 150 meters of heavily traveled freeways, one truck at 55 miles per hour sounds as loud as 28 cars traveling at the same speed. Although barrier walls are a common mitigation strategy, noise compatible land use planning is another alternative. This strategy both encourages the location of less noise-sensitive land uses next to highways and promotes the use of open space to minimize noise impacts (Federal Highway Administration 2002).

With respect to the PSRC growth alternatives and targeted growth areas transected by urban freeways, does this bring us back to a similar issue as with microscale air quality; “does infill create a “coming to the nuisance?” Or in the case of freeway expansion is the “nuisance coming to populations”?

Section 2. Summary of Literature Review Regarding Adverse Health Impacts within Urbanized Areas

This summary is intended to provide an understanding of the scope of adverse health effects rather than reflect a comprehensive list.

Adverse Health Effects	Study Findings	Study Area/ Scope	Reference
Respiratory	Children within 100 m of truck traffic had reduced lung function.	Six residential areas in the densely populated Province of South Holland	Brunekreef et al. 1997
	Pronounced respiratory symptoms in children living within 100 m of freeway.	Six residential areas in the densely populated Province of South Holland	Roorda-Knape et al. 1998
	Respiratory symptoms in children with allergies exasperated by proximity to busy roads.	City districts within central southwestern part of the Netherlands	Janssen et al. 2003
	Cough, wheeze, and doctor diagnosed asthma were significantly more reported for children living within 100 m of major roads.	Major freeways in the Province of South Holland.	van Vliet et al. 1997
	High incidence of wheeze amongst children living within 90 m of busy road.	Nottingham, U. K.	Venn et al. 2001
	Children under 4, admitted to the hospital for asthma are more likely to live in an area with high traffic flow.	Birmingham, U.K.	Edwards et al. 1994
	Exposure to diesel exhaust lead to reduced lung function and aggravation of asthma symptoms.	Oxford St in London, U.K. where only diesel buses, taxis and pedestrians are permitted	Jhang et al. 2005
	Respiratory symptoms more prevalent amongst individuals residing within 20 m of major roads in suburban Tokyo.	Kannana-dori Ave within several residential areas of Tokyo, Japan	Nitta et al. 1993
	Proximity to high traffic flows related to an increase in repeated medical visits for asthma.	San Diego County, CA	English et al. 1999
	Exposure to high volumes of traffic/trucks within 200 m of homes contributes to childhood asthma hospitalizations.	Eerie County, N.Y.	Lin et al. 2002
	Traffic related air pollution is associated with respiratory symptoms in children.	San Francisco Bay Area, CA	Kim et al. 2004
Respiratory health in children is adversely affected by local exposure to outdoor NO ₂ or other freeway-related pollutants	10 communities in Southern California	Gauderman et al. 2005	
Cardiovascular	Adults who live near a main road were almost twice as likely to die from hear or lung disease	Participants from 29% of the municipalities in the Netherlands	Hoek et al. 2002
	Diesel fumes significantly damage blood vessels, increasing the risk of heart disease for urban cyclists.	Cycle paths along bus lanes in London, U.K.	British Heart Association, 2005
	An association between exposure to ultrafine particles and cardiovascular morbidity in the population with chronic heart diseases.	Australian Government, Health Impacts of Ultrafines	Morawska et al. 2004
	Ultrafine particle exposure may precipitate acute cardiovascular responses ranging from increased blood pressure to myocardial infarction.	Review of epidemiological literature.	Delfino et al. 2005
Low Birth Weight	Increase of low birth weight infants associated with residential proximity to high traffic sources.	Los Angeles County, CA	Wilhelm and Beate 2003
Heat-related	Excess heat related death rates in Seattle, Washington, have actually increased compared with the 1960s-1970s.	Heat related mortality trends for 29 major U.S. cities.	Davis et al. 2003
Noise	Overview of the adverse health effects of noise with emphasis on the growth of urban environmental noise.	International study	World Health Organization, 1999

Section 3. Potential Mitigation Strategies

a) *Microscale Air Quality*

It does seem paramount that prior to initiating any mitigation strategy, there's a broad understanding of the scope of the problem. Some questions arise:

- What guidance can be provided regarding incompatible land uses next to high volume traffic?
- Does it make sense to site a day care center or school within proximity to urban freeways without at least asking the question of the dispersion patterns of vehicle pollutants?
- Can the question even be simply answered when dispersion is influenced by such variables as temperature, topography, atmospheric stability or wind speed and direction?

If we assume the development of compact urban centers that support pedestrian and mass transit mobility, we cannot also assume the elimination of motor vehicle traffic, either commercial or private, especially on urban freeways. The issue, then, may be one of understanding incompatible land uses within the nexus of transportation, air quality and populations.

- Incompatible Land Use:

The California Air Resources Board recently released the "*Air Quality and Land Use Handbook: Community Health Perspective.*" that provides guidance on incompatible land uses within proximity to air pollutants from heavy traffic sources. Least this study is dismissed as an issue peculiar to the population density and traffic volumes of southern California, there is also this spatial relationship between populations, traffic and air quality within the Puget Sound region.

- Education:

Brian Stone reported in his article *Air Quality by Design* that only 7% of accredited planning programs in North America offer specialized course work in air quality planning, (Stone Jr. 2003). For broad understanding of air quality issues within the urban context, another important step might be found with improvement in the academic planning curriculum. Considering the lack of air quality education in planning schools, then it is likely that urban planners are not familiar with the interdisciplinary relationship of planning and air quality, except what might be understood through contemporary initiatives. Air quality education for planning practitioners would assist in a broader understanding of incompatible land uses.

- Technological Advances:

Least there is an impression that no progress is being made, it is important to mention several initiatives. The Puget Sound Clean Air Agency has led in the introduction of *Diesel Solutions*, developed in cooperation with U.S. EPA's voluntary retrofit program to assist the conversion of public and private fleets to clean burning fuels, including school buses, waste collection trucks and transit buses (PSCAA 2003). Diesel Solutions partners include Seattle and Tacoma Port Authorities, Pierce Transit, Kitsap Transit, King County metro, the City of Seattle, the City of Tacoma and the Boeing Company just to name a few. Also in 2007, the U.S. Environmental Protection Agency will be implementing its rule on clean fuel requirements for heavy duty trucks and buses.

- Other Initiatives

The design of greenbelts are not new, however, as congestion continues to be resolved in part by freeway expansions and the expansions occur in the greenbelt area then obviously this reduces or eliminates its effectiveness as a buffer zone. Interestingly, Japan's Ministry of Land,

Infrastructure and Land Use is aggressively pursuing through the land purchase, the construction of green belts (MLIT 2002). Another important mitigation strategy can be found in the Las Vegas settlement agreement. Since indoor air quality is oftentimes reflective of outdoor air quality, air filtration systems will be installed in the three elementary schools that will be next to the expanded freeway.

b) Urban Canyons

Due to the vertical barrier of tall buildings pollutants trapped in street canyons cannot easily flow out without horizontal flushing provided by cross streets or spacing between buildings. Interestingly, the City of Toronto's *Environmental Improvement Strategy* also suggests minimizing street canyons through sloping away the building façade from the street allowing for better crosswind removal of pollutants (City of Toronto 2003). Perhaps another approach is designing tall narrow buildings with adequate spacing for cross wind movements. However, a discussion of mitigation strategies is hindered without comprehensive air monitoring / modeling data. Nevertheless, as VISION 2020+20 plans to the future, today's emerging issues should be considered.

c) Heat Island

- Vegetation

The inclusion of open space with shade trees is a common strategy to mitigate the heat island effect. VISION 2020 +20 includes open space connectivity in its environment assessment but the limitations of the modeling tools becomes evident with similar data for all four growth alternatives. Another mitigation tool is the installation of green roofs, which is becoming an increasingly common trend in the Puget Sound area.

- Technological Advances:

Advanced roofing systems has been designed to reduce the heat island effect from buildings and throughout the country incentive programs have been initiated to encourage installation of such materials. Paving materials are also available to minimize the absorption of solar heat on roads and parking lots.

d) Noise

The potential mitigation measures for noise are similar to microscale air quality and include:

- Understanding incompatible land uses through improvement in planning education.
- Stressing the importance of greenbelts as buffers.
- Technological advances for noise abatement include noise insulation in building construction; barrier wall design; road paving materials; and tire technology.

Corrective mitigation of the adverse health effects of urbanization may be costly, so as we look to the future in VISION 2020+20 it seems prudent to first evaluate the effectiveness of different mitigation strategies. This requires incorporating a range of complex issues within the environmental assessment of the various growth alternatives.

Section 4. Potential Future Research Topics

Vision 2020+20 forecasts 40 years into the future so one might anticipate technology improvements such as cleaner fuels and combustion processes, however, it's in the getting there from here. Even recent advances in reducing vehicle emissions have been offset by increasing vehicle miles traveled and traffic volume. Also competing with these technological advances is the emerging research on the adverse health impacts of ultrafines and air toxics, which may act independently, cumulatively or synergistically. Furthermore, current initiatives to investigate microscale air quality are minimal at best, including the phenomenon of urban canyons. The evaluation of the alternative growth scenarios would benefit from a more refined understanding of traffic pollutants, their behavior and their adverse health effects. Some of possible research questions to contemplate:

- Thinking Regionally / Acting Locally

Are planning agencies receiving guidance on the impacts of growth as related to land use and traffic pollutants at the local level? What about the emerging issue of urban air canyons?

- What are incompatible land uses?

Are there land uses such as schools, day care centers, residential complexes or retirement homes that should not be sited next to high traffic sources?

- Technology – Salvation or Revelation?

While technology continues to provide improvements, we should not ignore the possible advances in our understanding of environmental health such as the potential impact of cumulative air pollutants or the emerging research on the health impacts of ultrafines.

Conclusion:

The purpose of this paper is to broaden the discussion of the potential adverse health impacts of compact growth at the local scale where that sense of place and community begins. Are there “tradeoffs” as posed by Dannenberg or can compact growth in the Puget Sound region provide for healthy, vibrant communities for all? The Puget Sound Regional Council envisions, within its VISION 2020+20 update, a growth alternative that is inclusive and sustainable. Perhaps an examination of these potential adverse health effects within its Environmental Impact Assessment will aid in that process.

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