HEALTH IMPACT ASSESSMENT ON TRANSPORTATION POLICIES IN THE EUGENE CLIMATE AND ENERGY ACTION PLAN

A collaborative project of Upstream Public Health, the City of Eugene Office of Sustainability, Community Health Partnership: Oregon's Public Health Institute, and Lane County Public Health.

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ABOUT THIS PROJECT

This project examines the health benefits and negative impacts of transportation recommendations within the Eugene Climate and Energy Action Plan (CEAP). It examines seven objectives within the CEAP and summarizes the scientific evidence that links those policies to health issues in Eugene. Those health issues include injuries and chronic cardiovascular and respiratory diseases and will be impacted by the CEAP objectives through changes in collision rates, physical activity, and air pollution.

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EXECUTIVE SUMMARY

Eugene's Climate and Energy Action Plan and Health

In the fall of 2010, the Eugene City Council will vote on whether or not to adopt the Eugene Climate and Energy Action Plan (CEAP). The goals of the plan are to: reduce greenhouse gas emissions, reduce fossil fuel use, and adapt to climate change and rising fuel prices. The plan includes over 30 objectives to meet these goals, along with the estimated costs of and estimated greenhouse gas reductions for many of the objectives.

In addition to reducing greenhouse gas emissions, many objectives of the CEAP will impact the public's health. Research has shown that policies aimed at reducing greenhouse gas emissions can result in increased physical activity, better air quality, and fewer vehicle collisions as people drive less and increasingly walk, bike, or take public transit for transportation. These changes, in turn, can improve the health of Eugene residents by reducing the burden of chronic diseases (such as diabetes and heart disease), improving cardiovascular and respiratory health, and reducing injuries.

Upstream Public Health received funding from Community Health Partnership: Oregon's Public Health Institute (CHP:OPHI) to examine the health benefits and costs associated with the transportation recommendations in the CEAP. Upstream worked collaboratively with the City of Eugene Office of Sustainability, CHP:OPHI, Lane County Public Health, and others to conduct this analysis. The goal of this HIA is to inform the Eugene City Council's decision to approve, modify, or reject the CEAP by examining how the CEAP will impact public health and by suggesting strategies to best improve the health of Eugene residents while decreasing greenhouse gas emissions in Eugene and the surrounding area.

Methodology of the Study

A health impact assessment (HIA) is a tool used to inform policy debates and promote decisions that are the most beneficial to health. HIAs typically consist of six stages as recommended by the Centers for Disease Control and Prevention: screening, scoping, assessing, developing recommendations, reporting, and evaluating.[1]

In the screening stage, it was determined that the HIA had the potential to inform the debate about the CEAP and could influence the decision to approve, modify, or reject the plan. In the scoping stage, it was decided to limit the analysis to the transportation recommendations in the CEAP and to focus on health impacts related to physical activity, air pollution, and collisions, especially as these impacts related to vulnerable populations.

The assessment phase included data collection for existing conditions in Eugene and a literature review to examine the scientific evidence of the potential impact of the CEAP objectives. For each of the selected objectives, this report includes information about current conditions in Eugene and a description of how the CEAP objective will impact health. The report will be disseminated to policymakers and key community stakeholders in Eugene, as well as to state and national partners.

Recommended Policies for Health

Recommendations highlighted in this report include: (1) the Transportation and Land Use objectives of the CEAP have broad benefits for health and should be approved, (2) strategies to decrease greenhouse gas emissions through active transportation have greater health benefits than strategies to increase the use of low-emissions vehicles, and planning agencies should set active transportation targets that are linked to greenhouse gas emission reductions, (3) increased urban density can improve health, but strategies should be put in place to prevent the negative health impacts that can accompany density, (4) investments in complete streets, safety improvements, and in increasing the connectivity of pedestrian and bicycle infrastructure should be a high priority, (5) public transit investments should be prioritized to benefit low-income and other vulnerable population centers, (6) integrate health impact assessment practice into current land use and transportation planning at the state and local level, and (7) develop a system to track injuries and fatalities by transportation mode, to evaluate plan implementation and systematically improve bicycle and pedestrian outcomes.

Introduction

A health impact assessment (HIA) is a tool used to inform policy decisions and promote decisions that are the most beneficial for health. The purpose of this HIA is to address the health impacts of the Transportation and Land Use objectives of the Eugene Climate and Energy Action Plan (CEAP). These objectives are designed to reduce greenhouse gas emissions. While a reduction in these emissions will have direct impacts on health, an examination of those impacts is outside of the scope of this analysis. Instead, this report focuses on the health impacts that the CEAP objectives will have, independent of greenhouse gas reductions.

CLIMATE CHANGE POLICIES AND PUBLIC HEALTH

Government policies to mitigate and to adapt to the effects of climate change have the potential to benefit health in many ways. The aim of these policies is to directly reduce greenhouse gas levels through changes in the way we transport people and goods, the way we build and power our homes and other buildings, and the way we design our cities. Climate change-related transportation policies often aim to reduce motor vehicle use, support alternative modes of transportation, and lower emissions through use of alternative fuels.

In reducing greenhouse gas emissions, these transportation policies may mitigate some of the effects that climate change will have on public health. Climate change will cause increases in: heat stress; vector-borne diseases (carried by insects and animals); malnutrition and other health problems related to drought; respiratory and allergic disease; and developmental effects such as preterm birth and perinatal mortality.[2] [3] [4] [5] As the likelihood of natural disasters increases, affected populations will experience higher rates of injury, illness, and death that accompany disaster. Additionally, environmental refugees fleeing unsafe regions may speed the spread of disease and cause overcrowding in their new areas.[6] [7]

Those likely to be most impacted by these health issues include the young, the elderly, low-income households, those with pre-existing health conditions, and those with inadequate access to health care.[8] The homeless population, which often includes members of the before-mentioned groups, will also disproportionately suffer from the effects of climate change.[9]

Co-Benefits of Climate Change Policy

Climate change policies will benefit public health in ways that are not directly related to decreased greenhouse gas emissions – these benefits are known as co-benefits. Climate change policies focused on transportation offer a number of co-benefits. Reduced motor vehicle usage will lead to a reduction in air pollution caused by auto emissions. This will benefit air quality overall, leading to reduced rates of asthma, respiratory irritation, irregular heartbeats, and heart attacks. A reduction in air pollution will also lead to lower mortality rates, especially cardiopulmonary and lung cancer mortality.[10] [11]

Reduced motor vehicle usage will also result in a decrease in injuries and fatalities due to motor vehicle collisions. As people spend more time walking and biking instead of driving, physical

activity rates will increase. Increased physical activity will lead to a reduction in obesity and a reduction in chronic disease rates. Specifically, rates of colon and breast cancer, diabetes, stroke, and heart disease will decrease.[12] [13] Mortality rates will decrease as well, especially cancer and cardiovascular mortality rates.[14] [15] [16] [17] Moderate exercise, such as walking and cycling, reduces cigarette cravings," too; reduced smoking rates will have many health benefits for smokers and non-smokers alike.[18]

There are many reasons for policy-makers to carefully consider the health co-benefits of climate change mitigation and adaptation policies. Although there is general scientific consensus that human-caused climate change is happening, the possible outcomes of climate change (especially at the local level) are difficult to predict with accuracy. At the same time, the financial costs of many climate change mitigation and adaptation policies are easier to predict (and can be very high). This combination of high costs and unclear climate change benefits can stymie the development of innovative climate change policies.

Increasingly, though, communities are starting to examine the costs of not adopting adaptation and mitigation policies. A recent report by the Climate Leadership Initiative at the University of Oregon estimates that, if no action is taken in Oregon to adapt to or to mitigate climate change, resulting costs would reach $3.3 billion by 2020 and $9.8 billion by 2080. Health-related costs alone account for $764 million of the costs by 2020 and $2.6 billion of the costs by 2080, and these estimated health-related costs do not even include those related to "expanded range of tropical and sub-tropical diseases" or "increased incidence of water- and food-borne diseases".[19]

Even when the precise climate change benefits of a mitigation or adaptation policy are unclear, research and recent evidence predicts that many policies will have a positive effect on the health of the community. When these health benefits are taken into consideration, the cost/benefit comparison of climate change policy is likely to be significantly improved. In many instances, considering health benefits during policy development will provide decision-makers with more options and will encourage more innovative solutions. Considering health impacts before policy adoption may also save resources (time, money, and human lives) compared to addressing health consequences that stem from the policy at a later time.

Examining the Health Impacts of Climate Change Policies – Examples

There is a large and growing body of research examining the health impacts of climate change, but there are only a few examples of analysis of the health impacts of climate change *policy*. This HIA is the first completed on a local Climate Action Plan.

California

In California, researchers are working on a health impact assessment of the state's greenhouse gas cap and trade program.[i] In particular, the HIA will focus on air pollutant emissions, consumer economic impacts, employment, and land use and transportation.[20] The HIA will use statewide,

[i] Generally, cap and trade programs (also called emissions trading) set a mandatory cap on emissions in a region and then allow businesses to purchase credits or permits to emit greenhouse gases. Businesses can sell credits to or purchase credits from other businesses to change their allowed emissions.

regional, and community case studies and will be completed before the adoption of the rule. The purpose of the HIA is to "assess the potential impact of the cap-and-trade program on health including local impacts and strategies to maximize criteria and toxic pollutant reduction as well as other public health benefits to the extent feasible".[21]

Additionally, by fall of 2010, the California Department of Public Health plans to develop and distribute a health impact assessment guide to local health agencies. The department will also provide technical assistance in using HIAs "to assess land use, housing, and transportation activities and policies that could impact/influence community sustainability, public health, GHG emissions and community resilience for climate change".[22]

Oregon

In May of 2009, Upstream Public Health completed an HIA on policies to reduce vehicle miles traveled in Oregon metropolitan areas.[23] This was the first HIA that was completed on a climate change policy in the U.S. It examined local policies to reduce overall driving by: (1) increasing the cost of driving, (2) investing in public transit, or (3) modifying land use planning. The HIA examined impacts on health through changes in air pollution, physical activity, and collisions. Recommendations resulting from the analysis emphasized the need for a combination of the three types of policies but also highlighted the effectiveness of requiring businesses to charge a fee for employee parking. Recommendations also included: maximize the density of neighborhoods already within the urban growth boundary, require new developments to be mixed-use and high-density with good connectivity, improve the pedestrian infrastructure of neighborhoods, and increase the coverage area for public transportation across all of the metropolitan regions.

London and Delhi

An inter-disciplinary team of researchers examined the health benefits of climate change policies in London and Delhi.[24] They used a comparative risk assessment[ii] approach to estimate the impacts of the policies on physical activity, air pollution, and traffic injuries. They concluded that a combination of strategies to reduce driving rates and to improve fuel efficiency together had the largest benefit for health, because they measurably reduced both respiratory illnesses and heart disease.

Maryland

The state of Maryland's Climate Action plan is made up of 61 policies, one of which is to conduct HIAs on climate change policies. This policy is a key recommendation in the final plan: "Conduct health impact assessments to evaluate the public health consequences of climate change and projects and/or policies related to sea-level rise".[25] The plan notes that assessing the health benefits of climate change policies helps create a more collaborative working environment and involves more policy implementers from the very beginning.

[ii] Comparative risk assessment uses information about population demographics and the hazards of pollutants and exposure levels to predict impacts on health.

China

Researchers in China have examined recent policies aimed at reducing greenhouse gas emissions (in part for the 2008 Summer Olympics), in order to predict how an expansion of those policies would affect health in other areas of China. They examined household energy efficiency, industrial energy efficiency, building energy efficiency, and vehicle energy efficiency.[26] The authors concluded that full implementation of the climate change policies "could prevent 20,311 cardiopulmonary related premature deaths nationwide annually by 2020 and 29,239 by 2030" and could prevent "6,000 respiratory hospital emissions by 2020" and approximately 9,000 in 2030.[27] Just these two effects of the climate change policies could save more than $4 billion in costs.

POPULATION DEMOGRAPHICS

The previous examples highlight some of the ways that communities are considering the health benefits of climate change policies. In considering the health benefits of the CEAP transportation objectives, it is important to understand the characteristics of the population in Eugene and the existing conditions of the built environment that will be affected.

Eugene, with a 2008 population of 154,620, is the second most populous city in Oregon, after Portland. According to the Population Research Center at Portland State University, Eugene's population is likely to grow to 202,565 by 2035.[28] As the population grows, the share of the ethnic minority population (especially the Latino population) in Eugene is also likely to grow, following a trend that started in the 1990s. The share of the population that is 65 years and older is expected to increase from 12.1% in 2010 to 20.8% by 2035[29].

Overall, the population in Eugene is fairly similar to the population in Oregon as a whole, with two exceptions. Both the poverty rate and educational attainment level of Eugene residents are markedly higher than in Oregon as a whole. More demographic tables can be found in the Appendix.

Age

Children make up a smaller portion of Eugene's population, compared to Salem, Portland, or Oregon as a whole. Older adults make up a greater share of the population than in Portland or Oregon as a whole (**Table 1**).

Table 1: Percent Population by Age, 2008

Population	Eugene	Salem	Portland	Oregon
Under 18 Years Old	17.7	24.0	21.2	22.9
65 Years or Older	13.8	13.9	10.4	13.3

Data from the American Community Survey, 2008.[30]

Race and Ethnicity

The population in Eugene is 86.5% White, which is slightly higher than in Oregon as a whole (**Table 2**). The 14.5% non-White population and the Hispanic portion of the White population (4.3% of the White population) may experience some of the greatest benefits of climate change policies, because they are at greater risk of experiencing the negative health impacts of climate change. This disparity is due in part to the fact that these populations, on average, may have access to fewer resources to help them address rising fuel costs, heat waves, and other climate change impacts. For

example, for 2006-2008 the median income for Latino and Hispanic households in Eugene was $26,477 compared to $43,720 for White, non-Hispanic or Latino households.[31]

Table 2: Race and Ethnicity, 2006-2008 (Percent Population)

Race and Ethnicity	Eugene	Salem	Portland	Oregon
White	86.5	84.7	78.6	86.2
Black or African American	1.5	1.4	6.4	1.7
American Indian and Alaskan Native	1.4	3.0	1.4	1.8
Asian	5.0	2.6	6.5	3.5
Native Hawaiian and Other Pacific Islander	0.1	0.7	0.5	0.3
Some other race alone	1.8	4.3	2.9	3.2
Two or more races	3.6	3.3	3.7	3.3
Hispanic or Latino	6.7	17.9	8.8	10.6

Data from the American Community Survey 3 year estimates, 2006-2008

Income and Employment

The median household income in Eugene is $42,398. This is 85.0% of the median Oregon household income ($49,863). In comparison, median household incomes in Portland and Salem are 98.3% and 86.4% of the Oregon median household income, respectively.

In Eugene, 19.7% of people had an income in the past 12 months below the poverty level, while in Oregon as a whole 13.4% of the population had an income in the past 12 months below the poverty level. Eugene's poverty rate is also higher than Portland's and Salem's (15.2% and 16.4%, respectively). Non-white populations in Eugene had a higher rate of poverty than the White population for 2006-2008 (**Table 3**).

Table 3: Below Poverty Level in Eugene in the Past 12 Months, 2006-2008 (Percent Population)

Race and Ethnicity	Percent Population
White	18.5
Black or African American	N
American Indian and Alaskan Native	N
Asian	28.5
Native Hawaiian and Other Pacific Islander	N
Some other race alone	45.5
Two or more races	20.2
Hispanic or Latino	34.1

N "indicates that data…cannot be displayed because the number of sample cases is too small."
Data from the American Community Survey 3 year estimates, 2006-2008

The unemployment rate for Lane County in June 2010 was 10.6% when seasonally adjusted, compared to 10.5% in Oregon as a whole.[32] Historically, nationwide, "the jobless rate for blacks generally has been at least twice that for whites, whereas the unemployment rate for Hispanics has hovered between the rates for whites and blacks".[33] As mentioned above, low-income and racial and ethnic minority populations may reap a significant proportion of the benefits of climate change

policies, in part because they are at greater risk of experiencing the negative health impacts of climate change. These groups are also likely to experience greater health co-benefits of climate transportation policies, for reasons that will be explored in this report.

Educational Attainment

The population in Eugene has higher educational attainment levels than the population of Oregon as a whole and the population of the capital city of Salem (**Table 4**). The percentage of Eugene's population with a bachelor's degree or higher education is just below Portland's, and the percentage of Eugene's population that finished high school or more is slightly higher than in Portland.

Table 4: Educational Attainment, 2006-2008 (Percent Population 25 Years and Older)

Educational Attainment	Eugene	Salem	Portland	Oregon
High School Graduate or Higher	92.1	84.7	89.4	88.0
Bachelor's Degree or Higher	39.5	25.0	39.6	27.9

Data from the American Community Survey 3 year estimates, 2006-2008

COMMUNITY HEALTH

Health-related data is most often collected at the county level by the public health department. As a result, it can be difficult to disaggregate data down to the city or neighborhood level. Because the Eugene-Springfield population makes up such a large share of the population of Lane County (about 70%), county-level data can still be very valuable when considering the health impacts of climate change policy.

In Oregon, Lane County is ranked as the 17th healthiest county, where 1 represents the county with the best health, and 33 represents the county with the poorest health (three counties were not ranked). Lane is also ranked 17th for health factors, which include health behaviors, clinical care, social and economic factors, and the physical environment.[34] Multnomah County (including Portland) ranked 21st, and Marion County (including Salem) ranked 10th. In 2008, 13% of the population in Eugene had a disability, similar to 13.3% of the population of Oregon as a whole.[35]

Pediatric asthma hospital admission rates in Lane County in 2007 were considerably higher than in Oregon as a whole – 51.8 per 100,000 population compared to 41.3 in Oregon.[36] The percentage of residents in Lane that are overweight or obese is the same as in Oregon as a whole. Overweight, obese, and the diseases listed in **Table 5** are some of the primary health outcomes that are related to air quality and physical activity.

Table 5: Age-Adjusted Prevalence of Selected Chronic Diseases and Factors, 2007 (Percent Population)

Diseases and Factors	Lane	Marion	Multnomah	Oregon
Asthma	11	9	9	9
Diabetes	6	7	7	6
Coronary Heart Disease	3	4	4	4
Overweight	36	39	35*	37
Obesity	23	25	20*	22

*Statistically significant difference from statewide rate.
Data from BRFSS, Keeping Oregonians Healthy, 2007.[37]

While a smaller percentage of 8th graders in Lane County are overweight and at risk of overweight than in Marion County, Multnomah County, or Oregon as a whole, by the time youth reach 11th grade in Lane County, they are about as likely or slightly more likely to be overweight or at risk of overweight than 11th graders in Multnomah County or in Oregon as a whole (**Table 6**).

Table 6: Modifiable Risk Factors Among 8th & 11th Graders, 2005-2006 (Percent Population)

Grade	Risk Factor	Lane	Marion	Multnomah	Oregon
8th	At risk of overweight	14.8	16.0	15.3	15.3
	Overweight	9.3	13.3*	10.7	10.5
	Met physical activity recommendations	60.7	62.3*	55.1*	58.9
11th	At risk of overweight	13.1	13.9	13.2	13.0
	Overweight	10.6	12.0	10.2	10.7
	Met physical activity recommendations	52.1	51.7	40.4*	49.2

*Statistically significant difference from statewide rate.
Data from BRFSS, Keeping Oregonians Healthy, 2007.

Other important health outcomes affected by climate change policy include fatalities and injuries from collisions. Data examining fatalities and injuries by population that uses each mode is unavailable, but **Table 11** on page 26 includes information about injuries and fatalities from motor vehicle collisions in Eugene. This data does not include fatalities and injuries to bicyclists and pedestrians that occurred outside of motor vehicle collisions.

TRANSPORTATION BEHAVIORS AND INFRASTRUCTURE

In Lane County in 2004, 14.82% of all trips were less than one mile, and 14.77% of all trips were made without an automobile.[38] As seen in **Table 7**, non-auto modes make up over 30% of work commute trips in Eugene.

Table 7: Means of Transportation to Work, 2006-2008 (Percent Workers 16 Years and Over)

Means of Transportation	Eugene	Salem	Portland	Oregon
Drove alone	66.1	73.0	61.5	72.1
Carpooled	9.1	14.0	9.5	11.3
Public transit (not taxicabs)	6.8	3.2	12.2	4.2
Taxicab, Motorcycle, or Other means	0.6	0.7	1.7	1.3
Bicycle	7.1	1.9	4.7	1.6
Walked	6.4	3.6	4.9	3.8
Worked at home	4.0	4.0	6.3	5.8

Data from 2006-2008 American Community Survey 3-year estimates.

Bicycle rates vary significantly by city throughout Oregon. In the Lane metropolitan area, the ratio of bikeway miles (both on- and off-street) to arterial and collector[iii] miles (excluding freeways) was 59% in 2004.[39] As of February 2010, Eugene had a total of 41 miles of off-street paths, 33 miles of bike routes, and 81 miles of bike lanes. Compared to Salem, Portland, and Oregon as a whole, in Eugene, walking and bicycling make up a higher share of work commute mode.

Public transit rates also vary significantly by city. The average annual weekday transit trips per person in the Eugene metropolitan area in 2007 was 37, compared to 25 for Cherriots (Salem area) and 53 trips for TriMet (Portland area).[40] Many factors affect public transit use, including distance to stops, reliability of transit, and accessibility of destinations. Lane Transit District operates 42 bus routes in Lane County, a rapid transit bus between Eugene and Springfield, the RideSource service for individuals who cannot use the bus, and other services. Children under 5 and adults over 65 ride free.[41] In Lane County, 83% of households are within ¼ mile of a transit stop.[42]

OTHER BUILT AND NATURAL ENVIRONMENT FACTORS

The population density in 2000 in Eugene was 3,403 persons/square mile, compared to 2,994 persons/square mile in Salem and 3,939 in Portland.[43] Food access in Lane County is comparable to Marion County, but there are fewer zip codes with access to healthy food than in Multnomah County and in Oregon as a whole (**Table 8**).

Table 8: Physical Environment Health Factors, 2010

Health Factors	Lane	Marion	Multnomah	Oregon
Zip codes with access to healthy food*	38%	36%	45%	47%
Liquor store density**	0.4	0.4	0.7	0.5

* Healthy food outlets include grocery stores with more than four employees, produce stands, and farmer's markets.
** The number of liquor stores per 10,000 population (MATCH, 2010).

In 2009, the Eugene-Springfield area had eight days when the air quality was unhealthy for sensitive populations[iv] and one day when the air quality was unhealthy for the general public (**Table 9**). During days with air quality that is unhealthy for sensitive populations, these groups

[iii] A collector street moves traffic from residential streets into the arterial street system.
[iv] Sensitive populations include children, older adults, and other "groups of people who are particularly sensitive to the harmful effects of certain pollutants," such as those with lung or heart disease (Lane Regional Air Protection Agency, 2009).

may experience adverse health effects. In the Lane County Metropolitan area, there are 172.3 tons of carbon monoxide emissions each week.[44]

Table 9: Air Quality Index Summary, 2009 (Number of Days in Eugene-Springfield)

Year	Good	Moderate	Unhealthy (Sensitive)	Unhealthy
2009	321	35	8	1
2008	325	40	1	0
2007	321	40	4	0
2006	339	25	1	0
2005	294	69	2	0

Totals include Carbon Monoxide, Particulate Matter$_{2.5}$, and Ozone data
Data from Lane Regional Air Protection Agency, 2009.[45]

METHODOLOGY

Health impact assessments (HIAs) are used to evaluate the positive and negative impacts policies have on health. HIAs typically include the following six steps:

1) *Screening* – Determining the need and value of a HIA for a project or proposal.
2) *Scoping* – Determining which health impacts to evaluate, the methods for analysis, and the plan to complete the assessment.
3) *Assessing* – Using data, research, expertise, and experience to judge the magnitude and direction of potential health impacts on affected populations.
4) *Developing Recommendations* – Suggesting changes to the project or proposal to promote positive health impacts or to mitigate negative health impacts.
5) *Reporting* – Communicating the results to stakeholders and decision-makers.
6) *Evaluating* – Tracking the effects of the HIA on the decision and the impacts of the decision on health.[46]

Screening

In the screening stage, a potential HIA is evaluated to determine whether the analysis is feasible, timely, and would add value to the decision-making process, and a decision is made on whether to move forward with the analysis. The idea for an HIA on the transportation policies in the CEAP was brought up during a presentation in Eugene in October of 2009 and was initiated jointly by Upstream Public Health and the City of Eugene Office of Sustainability. Upstream Public Health with input from key stakeholders screened the project between October 2009 and January 2010.

In June of 2009, Community Health Partnership: Oregon's Public Health Institute (CHP: OPHI) was selected as a recipient of an award by the Centers for Disease Control and Prevention and the National Network of Public Health Institutes to conduct a series of HIAs on climate change, transportation and health policies, and to distribute lessons learned to national partners. CHP: OPHI chose to contract with Upstream Public Health in April of 2010 to conduct this project as one of the pilot HIAs on climate change, transportation, and health.

Feasibility

The HIA was screened to determine if adequate scientific evidence and sufficient resources were available to conduct the HIA. The City of Eugene identified key partners that could contribute to the analysis, including staff from Lane County Public Health, Lane Transit District, Lane Regional Air Protection Agency, Lane Coalition for Healthy Active Youth, and others. It was determined that there was significant interest among local agencies and community organizations to conduct the HIA.

Ideally, an HIA would be conducted on the entire CEAP, because policies from each section of the CEAP will have important health impacts. "Buildings and Energy" objectives have the potential to impact health through reduced greenhouse gas emissions and decreased home energy costs (leaving a larger share of household budgets for other needs). "Food and Agriculture" objectives will impact public health by supporting access to affordable, healthy food that is locally produced.

"Consumption and Waste" objectives will affect public health by reducing air pollution emissions related to waste disposal. "Health and Social Services" objectives will directly impact health, in part through increased emergency preparedness of public health and emergency response workers and residents themselves. "Urban Natural Resources" objectives will impact public health through the protection of trees, water quality, and air quality – all of which affect health.

Due to limited resources, though, this assessment focuses solely on the objectives in the "Transportation and Land Use" section. Upstream Public Health previously coordinated an HIA on policies to reduce vehicle miles traveled. This HIA of the CEAP transportation and land use policies benefits from Upstream's expertise and collection of relevant data to inform this project, which made the analysis of many of the CEAP recommendations feasible.

Timeliness

This project was designed to inform the decision by the Eugene City Council to approve, modify, or reject a draft Climate and Energy Action Plan in late 2010. It was determined that the HIA could be conducted in early and mid 2010 in order to inform this decision.

Relevance to Political Discussion

It was determined that an informed discussion about the health impacts, and in particular the health benefits, would be a valuable addition to the political discussion at the city council. In fact, because many of the environmental benefits of reduced greenhouse gas emissions in Eugene do not measurably benefit Eugene residents, the discussion of the immediate health benefits to local residents is very important. It was determined that an HIA could help to demonstrate local benefits to instituting the Eugene CEAP, independent of the impact on the global climate.

Additionally, this project represents the first HIA conducted on a local Climate Action Plan in the U.S. Therefore, it was determined that this project could serve as a model for other HIAs of climate change policies, and in particular HIAs on local and state Climate Action Plans.

Scoping

The geographic area of interest for this HIA was the City of Eugene in Oregon.

The Eugene Office of Sustainability and Upstream Public Health jointly coordinated the scope definition process. The scope of analysis was discussed with stakeholders in November of 2009. Key stakeholder organizations included the Lane Regional Air Protection Agency, Eugene Public Works Administration, Lane Coalition for Healthy Active Youth, and Lane County Public Health. The resources available to do the analysis and the short timeline to influence the city council limited the scope of the analysis.

This HIA focused on a subset of policies from the "Land Use and Transportation" section of the Climate and Energy Action Plan (CEAP) that were likely to affect health. The objectives and priority actions selected from the CEAP are listed in **Table 10**. Similar priority actions from certain objectives were grouped together for analysis: 1 and 2; 5 and 6; 8, 9, and 10; 11 and 12. The remaining priority actions were analyzed individually: 3; 7; 13; 14; and 15. This HIA does not examine "Objective 3: Consider the potential for climate refugees when doing land use planning."

There is little literature on the health impacts of Objective 3, and projecting the impacts of future refugee issues was too complicated to undertake within the scope of this HIA.

Table 10: Objectives and Priority Actions Included in the HIA

Objectives	Priority Actions	
Objective 1: Create 20-minute neighborhoods, where 90% of Eugene residents can safely walk or bicycle to meet most basic daily, non-work needs, and also have safe pedestrian or bicycle routes which connect to mass transit	1	Make the creation of 20-minute neighborhoods a core component of the Eugene Plan and the Eugene Bicycle Pedestrian Master Plan.
	2	By 2013, complete a 20-minute neighborhoods plan: a. Identify funding for necessary planning effort. b. Identify key accessibility components for 20 minute neighborhoods, e.g. schools, parks, grocery store, retail services, etc. c. Conduct a network gap analysis to determine needs. d. Coordinate with *opportunity siting and infill compatibility standards* planning.
Objective 2: Increase density around the urban core and along transit corridors	3	Zone future commercial and high-density residential uses in and around the urban core, and along EmX and other high-capacity transit corridors to accommodate future urban growth. a. Coordinate with *opportunity siting* and *infill compatibility standards* planning efforts.
Objective 4: Continue to expand and improve Eugene's bicycle and pedestrian infrastructure and connectivity to increase the percentage of trips made by bike and on foot.	5	Create a pedestrian and bicycle master plan that will: a. Identify mobility gaps in the bicycle and pedestrian transportation system. b. Recommend improvements to increase safety (both real and perceived), comfort, speed, and convenience for users of all ages and skill levels. c. Create a plan for implementing the necessary system improvements. d. Identify funding sources for implementation
	6	Increase the mileage and connectivity of bicycle boulevards and shared-use paths to encourage cyclists of various skill levels to commute by bike.
	7	Create a "Complete Streets" policy that requires all new transportation projects and rehabilitation projects to incorporate bicycles, pedestrians, and mass transit service.
Objective 5: Increase the supply of frequent, reliable, integrated and convenient public transit	8	Diversify funding sources for Lane Transit District (LTD) to increase the long-term reliability of mass transit service. a. Partner with Springfield, Lane County, LTD, and businesses to develop strategies for providing mass transit for the Eugene community.
	9	Align City of Eugene Transportation System Plan and LTD Long Range Transit Plan to integrate bus routes into the broader alternative transportation system. a. Partner with LTD to help inform service changes and improvements. b. Create special *setbacks* along future *Bus Rapid Transit (BRT)* or other mass transit corridors to accommodate future right-of-way expansion. c. Work with LTD in developing the Long Range Transit Plan to determine the role of mass transit in accomplishing greenhouse gas emission reduction goals.
	10	Invest in transit infrastructure that meets future access and mobility needs while consuming less fossil fuel. Recommended actions include: a. Maximize electrification of the regional transportation systems. b. Increase use of hybrid vehicles, including buses and other heavy vehicles.
Objective 6: Expand outreach, marketing and	11	Increase promotion of bicycling, walking, mass transit, car-pooling, telecommuting, high-occupancy vehicles, and emergency ride home

education regarding climate-friendly transportation alternatives	11	programs as attractive alternatives to driving, in order to increase the mode share of alternatives to the single-occupant vehicle. Partner with Point 2 Point Solutions, Lane Transit District, Greater Eugene Area RiderS (GEARS), BikeLane Coalition, local businesses, the City of Eugene Smart Trips program, Safe Routes to School, Lane Coalition for Healthy Active Youth, Lane County Public Health, Climate Masters at Home™, and others.
	12	Increase the community's understanding of fuel-efficient driving techniques.
Objective 7: Ensure maximum efficiency in current and future freight systems	13	Plan for efficient freight transportation that minimizes greenhouse gas emissions and fossil fuel consumption, and: a. Connects multiple modes (train, truck, van, car, bicycle); b. Accommodates regional (upper Willamette Valley) commercial, industrial and agricultural freight needs; and c. Facilitates efficient local deliveries.
Objective 8: Increase the use of low-carbon vehicles and fuels to improve overall fuel efficiency and reduce vulnerability to fluctuating oil prices	14	Accelerate the transition to plug-in hybrids and electric vehicles. Partner with Lane County, EWEB, auto retailers, electrical contractors, UO, LCC, and others. a. Support the installation of a network of electric car charging stations. b. Require installation of electric car charging stations in new multifamily housing.
	15	Conduct research to understand what role biofuels can play in decreasing Eugene's vulnerability to energy markets. Work with partners at LTD, the Oregon Department of Energy, etc. a. Complete research by 2013 so that outcomes can inform the next CEAP.

The HIA focused on the impact the objectives and policy actions would have on health through changes in air pollution, physical activity, and collisions. Changes in noise levels, stress, household budgets and access to healthy food, goods, and services will also have important health impacts, but analyzing those impacts was outside of the scope of this HIA.

Assessment

Although assessment often includes the magnitude and the direction of health effects, this analysis describes the types of health impacts but does not assess the magnitude of those impacts, due to a lack of clear prospective data.

Data Collection

If available, existing conditions data for the city of Eugene was the first choice, followed by the metropolitan area of Eugene-Springfield, and lastly by Lane County. Data on existing conditions were collected from a variety of sources: US Census, US Environmental Protection Agency, National Transit Database, Department of Transportation, Oregon Department of Environmental Quality, Oregon Department of Administrative Services, and Oregon Department of Human Services.

Literature Review

For each set of policy actions, a literature review was carried out to find current research on the topic. Several policy actions have overlapping topics, thus they did not all have separate search strategies. The following searches were carried out during the review: built environment and physical activity; built environment and air pollution; built environment and collisions; public transit and physical activity; promotion and active transportation; plug-in vehicles and air pollution; and biofuels and air pollution. Less intensive searches were carried out for the impact

the policies would have on vulnerable populations and the relationship between diesel fuel and air pollution.

The Built Environment and Physical Activity

Due to the large body of literature, the search on the built environment and physical activity was restricted to reviews. Ovid Medline was searched with the following search terms: "exercise (exploded)"[v] or "bicycling (exploded)" or "walking (exploded)" and "social planning (exploded)" or "environment design (exploded)" or "built environment (keyword)." After examining abstracts, full articles, and reference lists of relevant reviews, 11 review articles formed the literature base for the built environment and physical activity sections.

The Built Environment and Air Pollution

Two searches were conducted in Pubmed Medline with the keywords "built environment air pollution" and "air pollution road proximity." An additional search was performed in Transportation Research Information Services (TRIS) with the following keywords: "air pollution road proximity" and "air pollution and built environment." After examining abstracts, full articles, and reference lists of relevant articles, 20 articles formed the literature base for the built environment and air pollution. These articles were further restricted to those that addressed the characteristics typical of 20-minute neighborhoods (see page 22 for a description of a 20-minute neighborhood) and the bicycle and pedestrian infrastructure, leaving six articles for the final literature base.

The Built Environment and Collisions

Ovid Medline was searched with the following terms: "accidents, traffic" and "social planning" or "environment design" (all exploded) or "built environment" (keyword). An additional Ovid Medline search was conducted with "accidents, traffic" (exploded) and "sprawl" (keyword). The Human Impact Partners evidence base (http://www.humanimpact.org/EvidenceBase) was also searched, and one report from its reference list was used.[47] The search resulted in 19 articles. After the topic was restricted to 20-minute neighborhoods and bicycle and pedestrian infrastructure topics, nine articles remained.

Public Transit and Physical Activity

The reference lists from the "Built Environment and Physical Activity" reviews were used to find articles on public transit and physical activity. A search was also completed using Google Scholar with search terms "public transit physical activity." One article from the Google Scholar search was particularly relevant,[48] and this article was used in PubMed Medline to extract other articles that were related. Fourteen articles formed the final literature base for public transit and physical activity.

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v When a search term is "exploded," the search will include terms that are related to the original search term. For example, "exercise (exploded)" would also return articles that included "physical activity" as a key term.

Promotion of Active Transportation

Google Scholar was searched with "promotion active transportation." A relevant review on promoting active transportation[49] was used in Pubmed to find related articles. Pubmed Medline was also searched with "promotion active transportation." A particularly relevant American Journal of Preventive Medicine supplement was reviewed (Volume 37, 6S2). Six articles formed the final evidence base for promotion.

Plug-in Vehicles and Air Pollution

A search of Pubmed Medline using the keywords "plug in vehicle air pollution" yielded one article.[50] A related citations search was used to find additional articles in Pubmed Medline. Reference lists were also reviewed for relevant articles. An Ovid Medline search was also conducted with the keywords "electric vehicle." The final evidence base for plug-in vehicles and air pollution included two articles and one technical report.

Biofuels and Air Pollution

A search of Ovid Medline using the exploded terms "bio fuels" and "air pollution" yielded one article.[51] Ovid Medline was also searched with "air pollution" exploded and "biodiesel" as a keyword. A review of biodiesel emissions published by EPA was also used. The final evidence base for biodiesel and air pollution includes four articles. Ovid Medline was also searched using the exploded terms "ethanol" and "air pollution." The final evidence base for ethanol and air pollution included three articles.

Recommendations

Recommendations based on the assessment of the selected objectives can be found at the end of this report. The recommendations are designed to maximize health benefits while decreasing greenhouse gas emissions and were revised to reflect feedback received at a community forum in July 2010, and from input on the draft HIA report. At the July Forum, approximately 30 participants representing transportation, public health, environment and architecture expertise as well as unaffiliated concerned citizens heard a presentation on the draft proposal and provisional recommendations and had an opportunity to provide oral and written feedback to inform the recommendations.

Reporting

The results of the report are organized as in **Table 10**; certain priority actions are grouped together, and some are analyzed individually. For each objective, the report explains how changes stemming from the objective will ultimately affect community health. In the figures that show the pathways from CEAP objectives to community health, the solid lines mean that there is a consistent evidence base for the association. The dashed lines mean that the association is speculative or that there is not enough evidence to strongly support the association. Where the data is available, the report explores related existing conditions in Eugene or in Lane County.

Throughout the report, where "good land use mix" is mentioned, it refers to a mix that generally includes destinations of interest to residents, like grocery stores, restaurants, entertainment, etc. "Higher residential density" does not refer to a specific density; generally, increasing residential

density is associated with more walking. "Accessibility" and "accessible" refer to features and environments that are safe and convenient to use because they offer several mobility options, have a well-connected street and/or sidewalk network, and are close to destinations. These terms do not refer to the Americans with Disability Act accessibility standards.

The report will be disseminated to the Eugene City Council, interested citizens and activists, and national, state, and local groups with an interest in examining the health impacts of transportation policies related to climate change. The report will be included as an appendix in the CEAP, and electronic copies will be available on Upstream Public Health's website: http://upstreampublichealth.org.

The City of Eugene Office of Sustainability plans to coordinate the release of a media advisory. In addition, the results will be submitted in the future to a scientific journal article and relevant regional magazines.

Evaluating

A limited evaluation of the HIA will be conducted after the Eugene City Council's final decision regarding the CEAP. This evaluation will examine the impact of the HIA on the CEAP decision-making process and the relevance of the HIA to area transportation planners. A set of evaluation questions will be developed with input from the key participants in the HIA and distributed to planning, health and environmental stakeholders in Lane County.

RESULTS

Objective 1: Create 20-minute neighborhoods, where 90% of Eugene residents can safely walk or bicycle to meet most basic daily, non-work needs, and also have safe pedestrian or bicycle routes which connect to mass transit

Priority Action 1: Make the creation of 20-minute neighborhoods a core component of the Eugene Plan and the Eugene Bicycle Pedestrian Master Plan.

Priority Action 2: By 2013, complete and implement a 20-minute neighborhoods plan:

a. *Identify funding for necessary planning effort.*
b. *Identify key components for 20 minute neighborhoods, e.g. schools, parks, grocery store, retail services, etc.*
c. *Conduct a network gap analysis to determine needs.*
d. *Coordinate with opportunity siting and infill compatibility standards planning.*

The 20-Minute Neighborhood

Cities across the country are using the 20-minute neighborhood concept as one way to think about neighborhood livability and future sustainability. Definitions vary but often include: walkable destinations that meet everyday needs (e.g. grocery store, school, park, bank, library, doctor's office); other retail destinations; and a well-connected, pleasant, and safe pedestrian and bicycling environment that offers several mobility options. The CEAP defines 20-minute neighborhoods as "those in which a significant number of regular trips can be made in 20 minutes, without using a personal automobile."

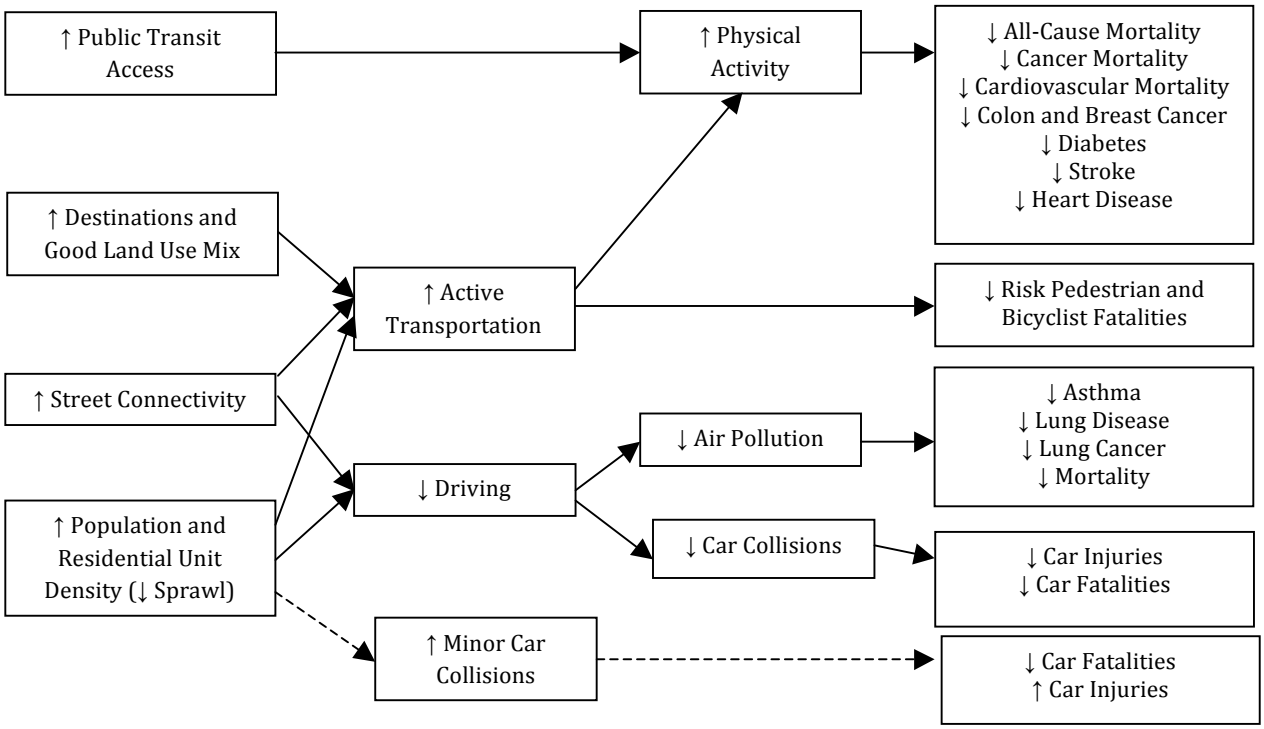
While the 20-minute neighborhood may be easy to visualize, it can be very difficult to measure whether or not a neighborhood is a 20-minute neighborhood. "Conventional wisdom among planners has been that pedestrians in the United States will only walk a quarter to a third of a mile for any reason," but a recent study that examined how far pedestrians would walk to access rail transit in Portland and in San Francisco found that the median trip was 0.47 miles.[52] Individuals walk and cycle at different rates and are comfortable with different environments – where one neighbor feels safe, another may not. Also, just because a destination is nearby does not mean that it is affordable or culturally appropriate. As a result of these factors, a 20-minute neighborhood will not look the same for everyone.

To measure destinations and sidewalk and bike routes in a neighborhood, planners often look within a ¼-mile, ½-mile, and/or 1-mile radius from a home or center of a neighborhood or district. This data is used as a proxy for measuring if a neighborhood is a 20-minute neighborhood, and although it is an imperfect measurement for all of the reasons listed above, it can be a good starting point. Planners can use these measurements to compare different areas of the city and explore why some areas might be missing certain amenities near residences.

The characteristics of a 20-minute neighborhood are associated with increased physical activity, decreased collision fatalities, and lower levels of air pollution. These factors contribute to positive

health outcomes and are discussed in detail below. **Figure 1** shows the relationship between these policy actions and health. Depending on the design of the 20-minute neighborhood, there may be more or less vehicle collisions, but *fatality rates* from collisions decrease as "sprawl" decreases.[vi]

Figure 1: Pathway Between the Characteristics of 20-minute Neighborhoods and Health



Physical Activity

Nearby destinations and a good land use mix are both associated with higher levels of walking for transportation.[53 54 55 56 57 58] Even subjective[vii] accounts of these amenities are associated with higher levels of walking for transportation.[59]

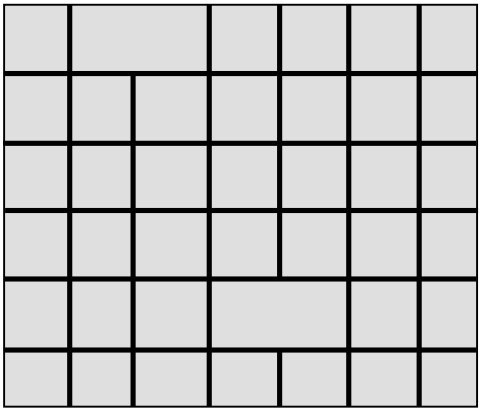
Nearby destinations may not be easy to walk to if they are not supported by good network connectivity – "the directness and availability of alternative routes from one point to another" – which could be achieved by street with sidewalks or pedestrian/multi-use paths that are separate from cars.[60] Residents need to be able to access nearby amenities easily, and having multiple pathways to get from one point to another increases the amount of walking.[61 62] In Lane County, the median block length of the census tracts within the county ranges from 1,206 feet to 20,813 feet (data from the RAND Center for Population Health and Health Disparities).[63] A typical block length in a compact, downtown urban area is 200-300 feet.[64] For more detailed information on street connectivity, see **Figure 2** and the Appendix.

[vi] See the "Collisions" section on page 25 for a definition of "sprawl".

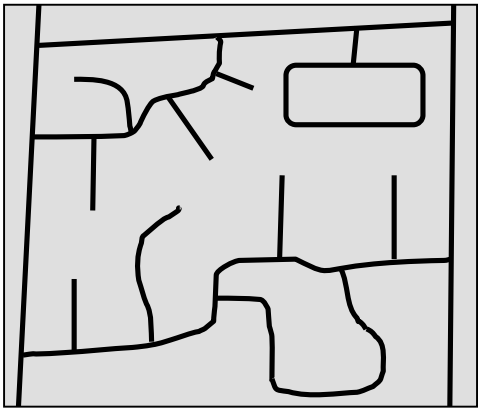
[vii] A subjective account or report is data collected from personal accounts, as compared to an objective report that relies on observed and measurable data (such as distance to a bus stop).

Figure 2: Examples of high and low street connectivity.

Highly Connected Street Network:



Poorly Connected Street Network:



Increasing access to public transit, through increased density of transit stops, closer proximity to stops, and ease of access to transit stations, benefits health in several ways. Increased density of stops was related to meeting physical activity recommendations in a study of 50-75 year olds in Portland, OR.[65] Increased public transit accessibility is also associated with more walking for transportation and less motorized trips, indicating that the development of a dense, well-connected transit network will benefit those who use transit and those who do not.[66 67 68]

Additionally, transit use is associated with walking, often enough to meet public health recommendations for physical activity of thirty minutes or more of moderate activity five days per week.[69 70 71 72 73]

Overall, there is sufficient evidence that the characteristics of 20-minute neighborhoods are associated with higher levels of physical activity. Higher residential density, good land use mix, distance to nonresidential destinations, and access to public transit are characteristics consistently positively associated with physical activity.

According to data collected in 2002-2005, only 58.8% of adults in Lane County met the public health recommendation to achieve 30 minutes or more of moderate activity at least 5 days per week or 20 minutes or more of vigorous activity at least 3 days per week, and 58.7% of adults were either overweight or obese.[74] Making changes to the built environment that will encourage physical activity among Eugene residents will be an important policy action in the upcoming years.

Increasing levels of physical activity is associated with reduced all-cause mortality.[75 76 77 78] In addition, studies have found that physical activity is associated with reduced cause-specific mortality, including deaths from cardiovascular disease[79] and cancer.[80] Physical activity is also associated with lowered risk of colon cancer and breast cancer in women,[81] diabetes,[82] heart disease, and stroke.[83]

Vulnerable Populations

The characteristics of 20-minute neighborhoods can also be important for vulnerable populations, such as children and older adults. Access to destinations (including schools) has been found to be positively associated with physical activity levels in children.[84] In Lane County in 2005-2006, only 60.7% of 8th graders and 52.1% of 11th graders met physical activity recommendations.

Additionally, for older adults, more accessible neighborhood design supports greater levels of walking.[85] In a study of adults 50-75 years old in Portland, OR, an increase in land-use mix was associated with a reduction in overweight and obesity prevalence; in the same study, high street connectivity was related to meeting physical activity recommendations.[86] With a projected increase in the proportion of older adults and a nationwide childhood obesity epidemic, 20-minute neighborhood characteristics will be especially valuable to these populations.

Collisions

Areas typically considered "suburban" or "sprawl" are often lacking many of the characteristics of 20-minute neighborhoods and have higher traffic fatality rates compared with more compact areas, even after accounting for exposure[viii].[87] [88] Characteristics of sprawl include: "a population widely dispersed in low-density residential development; rigid separation of homes, shops, and workplaces; a lack of distinct, thriving activity centers, such as strong downtown or suburban town centers; and a network of roads marked by very large block size and poor access from one place to another".[89]

Neighborhoods that are more walkable can provide alternative forms of transportation, which can limit the amount of collisions simply through the fact that when people drive less, they are less likely to be involved in a collision.[90] Increased congestion can impact collisions through increasing the frequency of collisions, but due to slow speeds, the fatalities will be limited. However, reduced density of cars will allow them to travel faster, and could increase the number of fatal collisions.[91]

Pedestrians are more likely to be involved in a collision with increased vehicle flow.[92] [93] Risk of injury for child pedestrians is strongly associated with vehicle volume.[94] However, increased pedestrian and bicyclist flow is associated with decreased risk to pedestrians and bicyclists,[95] [96] possibly due to altered driver behavior when pedestrians and bicyclists are more common.[97] [98]

However, it has been noted that residential unit density and population density are associated with increased collisions[99] and increased pedestrian-vehicle collisions.[100]

In 2008, there were five fatalities from motor vehicle collisions in Eugene - one bicyclist, one pedestrian, and three motor vehicle occupants (**Table 11**). Because the number of bicycle and pedestrian trips would increase with the development of 20-minute neighborhoods and the investment in more and better bicycle and pedestrian infrastructure, it is possible that these factors would lead to an increase in the number of pedestrian- and bicycle-vehicle collisions. However, the overall risk of collisions for bicyclists and pedestrians would decline, so it would be safer for each

[viii] "Because pedestrian fatality rates depend on the amount of walking," the authors adjusted for exposure from walking.

individual bicyclist and pedestrian than it was before. Current trends in Portland, OR and in New York City, NY indicate that as bicycle ridership increases, the number of collisions (in addition to the rate) may be holding steady or decreasing.[101] [102]

Table 11: Fatalities and Injuries from Motor Vehicle Collisions in Eugene, 2004-2008

Year	Bicyclists		Pedestrians		Motor Vehicle Occupants	
	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities
2008	70	1	25	1	978	3
2007	56	2	23	2	1014	1
2006	60	0	29	1	911	4
2005	86	1	36	5	740	2
2004	53	2	19	0	428	1

Data from Oregon Department of Transportation Traffic Crash Summaries 2004-2008.[103]

Air Pollution

In a study of King County, Washington, researchers found that a 5% increase in walkability (based on mixed use, connected streets, high residential density, and pedestrian-oriented retail) was associated with a per capita 6.5% fewer vehicle miles traveled (VMT), 5.6% fewer grams of nitrogen oxides emitted, and 5.5% fewer grams of volatile organic compounds emitted.[104] People living in more walkable neighborhoods drove less and produced less air pollution than people living in less walkable neighborhoods.[105]

With increasing population density, diversity (here used as a measure of population/employment mix), and accessibility, VMT decreases.[106] A significant inverse relationship exists between vehicle emissions and household density and street connectivity.[107] By reducing VMT and vehicle emissions, these 20-minute neighborhood characteristics also reduce air pollution.

Increases in pollutants such as nitrogen dioxide (NO_2) and fine particulate matter (PM) have been associated with cardiopulmonary mortality.[108] [109] NO_2 has been linked to increased risk of lung cancer and non-accidental mortality,[110] and fine PM has been linked to all-cause and lung cancer mortality.[111] Decreases in fine PM are associated with increased life expectancy[112] and decreases in chronic coughing and phlegm, wheezing, and dyspnea.[113] See "Biodiesel" on pages 45-46 for more information about the effects of particulate matter on health.

In 2002, 62% of nitrogen oxides and 5% of particulate matter was attributable to on-road vehicles in Lane County (**Table 12**). Increasing the amount people walk and bike while simultaneously decreasing the amount they drive through the development of 20-minute neighborhoods will lower the current levels of these detrimental pollutants. Reducing pollution levels will become increasingly important to Eugene as new air quality standards are introduced.

Table 12: Percent of Selected Air Emissions that Come from On-Road Vehicles in Lane County, 2002

Emissions	Percent
Carbon Monoxide	68
Nitrogen Oxides	62
Volatile Organic Compounds	27
Particulate Matter	5
Sulfur Dioxide	19

Data from US Environmental Protection Agency, 2002.

Other Considerations

Building connected street networks requires the use of more concrete, asphalt, and other building materials. Although some of the negative impacts of increasing paved surfaces may be offset by the use of pervious paving materials, the production of both pervious and impervious materials is accompanied by greenhouse gas emissions. An increase in the use of these materials will result in negative health effects somewhere in the world, if not in Eugene.

While a connected street network designed for all users may support increases in pedestrian and bicycle trips, a network of pedestrian and bicycle infrastructure could also be developed separate from a network that accommodates cars. In this case, it may be possible to use fewer materials and still create a supportive environment for active transportation.

Urban design is a critically important factor in whether or not a 20-minute neighborhood is truly supportive of pedestrians and bicyclists. The Task Force on Community Preventive Services systematically reviewed and evaluated studies that "assessed the relationship between the perceived environment and physical activity practices, or effectiveness in providing a more inviting and safer outdoor environment for activity".[114] From the six studies ultimately assessed, the "median improvement in some aspect of physical activity (e.g., number of walkers or percent of active individuals) was 35%." Community-scale and street-scale urban design and land use policies were both found to affect physical activity. Effective design features include: improved street lighting; infrastructure projects to increase safety of street crossing; use of traffic calming approaches (e.g., speed bumps, traffic circles); enhancing street landscaping".[115]

Objective 2: Increase density around the urban core and along transit corridors

Priority Action 3: Zone future commercial and high-density residential uses in and around the urban core, and along EmX and other high-capacity transit corridors to accommodate future urban growth.

a. *Coordinate with opportunity siting and infill compatibility standards planning efforts.*

The policy actions included in Objective 2 address characteristics of the built environment, such as population and residential density, mixed-use neighborhoods, and public transit. The health benefits of these types of changes to Eugene neighborhoods are discussed in Objectives 1, 4 and 5 and include increased physical activity, decreased air pollution, and decreased collisions.

Other Considerations

While all residents in Eugene will likely benefit from changes that encourage urban density, a mix of affordable housing, retail services and employment centers, and access to public transit, vulnerable populations,[ix] such as older adults and low-income residents, will especially benefit from these changes. However, increased density may also affect health through an increase in the urban heat island effect.[x] Older adults are especially vulnerable during heat waves, so there is a chance that increasing density may adversely impact them and other vulnerable populations if accompanying measures to reduce the heat island effect are not taken.[116] These measures may include increasing tree, vegetation, and green space coverage and green roofs as well as the use of permeable pavement materials where possible.

Vulnerable Populations

Improving access to public transit can have a positive impact on low-income residents in Eugene, especially if transit access is linked to affordable housing. Low-income families in the United States spend a disproportionate amount of their income on transportation. In a recent study of working families (with a yearly income of $20,000-$50,000) in 28 metropolitan areas, the families spent 57.3% of their income on housing and transportation. This is nearly 10 points higher than the 47.6% of yearly income that all households in the study areas spent on transportation and housing combined.[117] If affordable housing were linked to better public transit, low-income residents would not need to spend as much on transportation.

A national survey found that African Americans and Hispanics use public transit or walk to travel to the doctor more than Whites do (16.5%, 24.0%, and 3.5% of respondents, respectively).[118] With a better mix of services near affordable housing, low-income residents and transit-dependent populations would not need to travel as far to reach services they need, further reducing the burden of transportation expenses. Given Eugene's relatively high level of poverty and the relatively low

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[ix] "The Agency for Health Care Research and Quality defines vulnerable populations as those who are made vulnerable by their financial circumstances or place of residence, health, age, personal characteristics, functional or developmental status, ability to communicate effectively, and presence of chronic illness or disability" (Dorsey, C. and Murd, C. (2003). The theory of self-care management for vulnerable populations. *Journal of Theory Construction and Testing*, 7(2), 43-49.)

[x] As an area develops and vegetation is replaced by impervious surfaces, such as buildings and driveways, these areas become warmer than surrounding areas that are less developed.

median incomes of Eugene's Hispanic and Black and African American households, it is important that any policy to increase density also promotes affordable housing and density in the right places to ensure low-income households are not priced out of the most livable neighborhoods.

Over the next 30 years, the population in Lane County will include an increasing percentage of older adults. The number of adults 65 years and older is expected to increase by 133% between 2000 and 2040. During that same time period, the population of 0-19 year olds is expected to increase by 19%, and the population of 20-64 year olds is expected to increase by 38%. Lane County is projected to have over 100,000 residents who are 65 years or older by 2040. In 2000, adults 65 years and older were 13% of the population, and by 2040 they will represent 21% of the population.[119]

A report that looked at the transportation patterns of older adults (age 65 and older) found that more than one in five older adults in America do not drive personal vehicles for reasons including declining health, concern over safety, and lack of a car. Additionally, over 50% of older adults who do not drive stay home simply because they do not have transportation, this is especially true of residents of sprawling or rural communities, households without a car, and persons of color. Compared with older adults who do drive, older adults who do not drive make 15% fewer trips to the doctor, 59% fewer shopping trips, and 65% fewer trips for social, family, and religious activities.[120] This can have a large impact on the social support older adults have available to them, their nutrition, and how they maintain their health.

Increasing density around the urban core and along transit corridors may benefit the health of Eugene residents, particularly those who are part of a vulnerable population. Measures to mitigate possible negative effects of density should be put in place in order to maximize health benefits.

Objective 4: Continue to expand and improve Eugene's bicycle and pedestrian infrastructure and connectivity to increase the percentage of trips made by bike and on foot.

Priority Action 5: Create a pedestrian and bicycle master plan that will:

a. *Identify the mobility gaps in the bicycle and pedestrian transportation system.*
b. *Recommend improvements to increase safety (both real and perceived), comfort, speed, and convenience for users of all ages and skill levels.*
c. *Create a plan for implementing the necessary system improvements.*
d. *Identify funding sources for implementation*

Priority Action 6: Increase the mileage and connectivity of bicycle boulevards and shared-use paths to encourage cyclists of various skill levels to commute by bike.

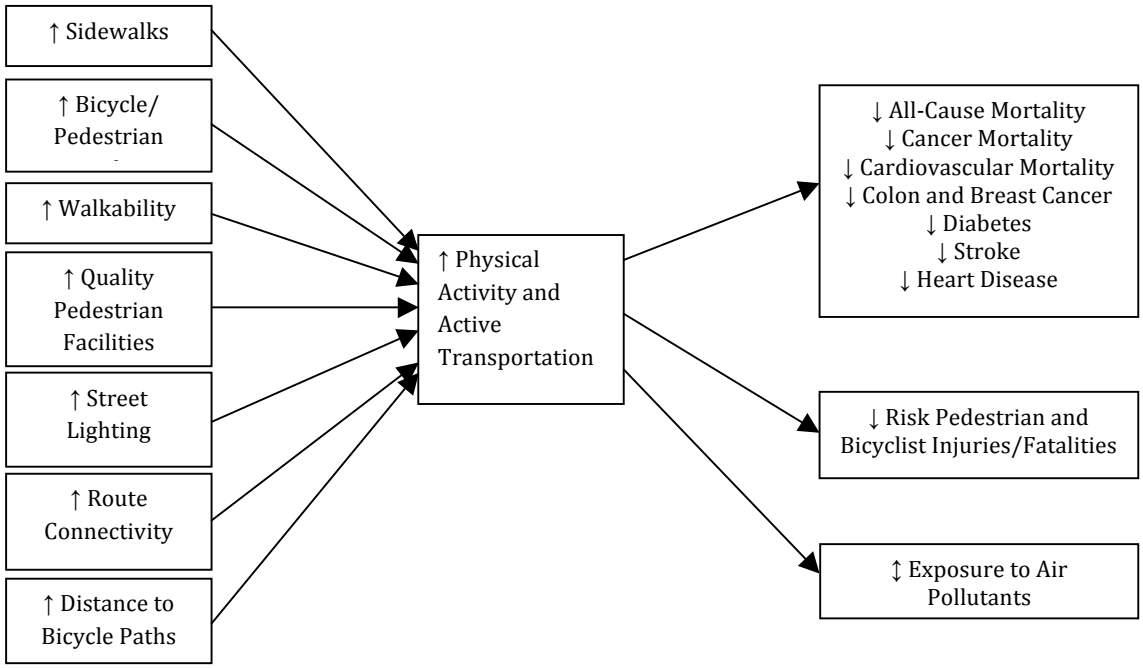
Although many daily trips are within walking and biking distance, most Americans prefer to use their personal vehicles to reach destinations. According to data collected in Eugene from 2006-2008, 7.1% of adults rode their bike to work, and 6.4% walked to work; the vast majority of adults traveled to work in a car.[121] Work commute data is often used as a proxy to represent overall pedestrian and bicyclist transportation choices. While distance is an important factor in determining whether an individual will use an active form of transportation or drive a car, another very important factor is the type of environment that they must ride their bike or walk through. Roads without sidewalks or wide shoulders are prohibitive to walkers and bicyclists. Busy roads can be discouraging, especially if crossing signals are not frequent. Large highways and freeways can make it very difficult, if not impossible, for pedestrian and bicyclist traffic to cross from one area to another.

Other countries have been successful in achieving high rates of walking and bicycling, largely due to policy changes similar to those associated with Objective 4 (Priority Actions 5 and 6). The Netherlands and Germany have both worked to improve infrastructure for pedestrians and bicyclists. For pedestrians, that has included: extensive auto-free zones that cover much of the city center; wide well-lit sidewalks on both sides of every street; pedestrian refuge islands for crossing wide streets; clearly marked crosswalks, often raised and with special lighting for visibility; and pedestrian activated crossing signals. For bicyclists the network of bike paths and lanes has been greatly expanded; a truly coordinated network of bicycle paths, lanes, and streets for both rural and urban areas has been developed; bike paths serve practical as well as recreational destinations; special bike turn lanes lead directly to intersections. Bicycle infrastructure also includes: separate bike signals with advance green lights for cyclists; bicycle activated traffic signals; modified street networks that create deliberate dead ends and slow, circuitous routing for cars but direct, fast routing for bikes. As a result, compared to the United States, Germany and The Netherlands have reduced collisions and have higher rates of walking and cycling, especially among older adults.[122]

In the Lane metropolitan area in 2004 the ratio of bikeway miles (both off and on street) to arterial and collector miles (excluding freeways) was 59%.[123] The 2002 Regional Transportation Plan reported that 58% of roadway miles had sidewalks, but this figure was not updated for the 2007 Regional Transportation Plan. These ratios suggest that there is an opportunity for Eugene to

greatly improve its bicycle and pedestrian infrastructure. Roads without sidewalks will be prohibitive to pedestrian travel, and the low ratio of bike miles to street miles means that bicyclists may have a difficult time choosing a route that feels safe. **Figure 3** summarizes the effect that good pedestrian and bicycle infrastructure will have on health. These pathways are discussed in greater detail below.

Figure 3: Pathway Between Pedestrian and Bicycle Infrastructure and Health



Physical Activity

Evidence suggests that sidewalks and bicycle paths increase the number of walking and cycling trips. When sidewalk continuity is used as one of the criteria for determining neighborhood walkability, highly walkable neighborhoods have higher rates of walking and cycling. In one study, better pedestrian facilities were related to higher pedestrian rates at commercial centers, even when other environmental characteristics were constant. Another study found that better pedestrian infrastructure, including sidewalks and street lighting, was related to greater non-automobile travel.[124]

The existence of sidewalks and the strong connectivity of routes/network are positively correlated with walking for transportation. Greater street connectivity generally means more direct routes and thus shorter distances from home to potential destinations. Street connectivity might also affect walking by expanding the choice of routes, providing variety in routes within the neighborhood or to destinations.[125] See page 24 and the Appendix for more discussion of street connectivity.

The perceived presence of sidewalks has been associated with participating in sufficient levels of physical activity among women, mixed samples, and older adults. The perceived presence of footpaths has also been found to be the most important neighborhood correlate of meeting

recommended levels of physical activity among higher income earners.[126] Presence of sidewalks has been found to be associated with walking for transport.[127] An accessible bike path is positively associated with physical activity, distance to a bikeway is negatively associated with physical activity, and safe footpaths are positively associated with physical activity.[128]

The Community Guide from the Task Force on Community Preventive Services determined that there was sufficient evidence that street-scale and community-scale urban design, such as safe and attractive pathways to reach destinations, bike lanes, and traffic calming, can be effective in increasing walking and bicycling.[129] See "Other Considerations" on page 27 for more information on community design and health.

Vulnerable Populations

Safe and accessible pedestrian and bicycle infrastructure can be important for vulnerable populations. Older adults, children and disabled persons are often dependent on forms of transportation other than a personal vehicle. Due to our automobile-dominated transportation system, these groups face a disproportionate burden of limited access to places in the community.[130] However, in other countries, older adults are much more likely to use active transportation for their travels; among Dutch older adults, bicycling accounts for 25% of all trips made.[131]

Low-income populations are also more dependent on other forms of transportation besides a personal vehicle. One in ten residents of Eugene does not own a car[132] and would greatly benefit from enhanced pedestrian and bicycle infrastructure.

In general, the literature supports a positive association between the presence and condition of sidewalks and children's physical activity. The literature does not provide strong evidence for bike paths and children's activity levels.[133]

Collisions

Increased pedestrian and bicyclist flow is associated with decreased risk to pedestrians and bicyclists,[134] [135] possibly due to altered driver behavior when pedestrians and bicyclists are more common.[136] [137] A study conducted by Jacobsen utilizing data from California, Denmark, The Netherlands, the United Kingdom, and several other European countries showed that the risk per bicyclist and pedestrian decreased with increasing numbers of bicyclists and pedestrians, and bicyclists and pedestrians were safer in towns where bicycling and walking were more common.[138] A study from Australia showed that when bicycling doubled, the risk of fatality and injury per kilometer fell by 34%, and when bicycling decreased by 50%, the risk per kilometer was 52% higher.[139]

A study conducted in Canada found that pedestrian risk decreased with increasing pedestrian flow, but the study cautioned that if promotion of walking is not accompanied by infrastructure that creates a safe environment for walking, increasing pedestrian flow could lead to more collisions involving pedestrians.[140] However, as mentioned in the "Collisions" section of the analysis of Objective 1, recent reports from Portland, OR and New York City, NY indicate that the increasing

number of cyclists in the last several years has not generated the expected increase in the number of collisions.[141] [142]

Air Pollution

Although it is possible that bicyclists and walkers could be exposed to higher levels of pollution in compact urban areas due to the high volume of vehicle traffic,[143] it is still possible that people choosing active transportation are not exposed to higher levels of pollutants compared to people in cars. A study conducted in Copenhagen, Denmark found that car drivers were exposed to higher levels of benzene, toluene, ethylbenzene, and xylene compared to bicyclists during morning hours.[144] Another study conducted in Amsterdam found that the uptake of carbon monoxide, benzene, toluene, and xylene was roughly the same for drivers as it was for bicyclists, although the uptake of nitrogen oxides was higher for bicyclists.[145]

Recently, researchers in the Netherlands modeled the effects of a shift of 500,000 people from making short trips by car to making those trips by bike instead. They found the reductions in all-cause mortality for those who "shift from car to bicycle use for short trips" to be substantially larger than the "potential mortality effect of increased inhaled air pollution doses" and the "effect on traffic accidents".[146]

Researchers at Portland State University are currently examining how roadway barriers (including sound walls) between motor vehicle and bicycle traffic affect cyclists' exposure to ultra-fine particulate matter.[147]

A reduction in all travelers' intake of air pollutants is important, regardless of the mode of transportation. Promoting the use of active transportation instead of personal vehicles should lower the vehicle volume and lower the levels of air pollution for everyone.

Other Considerations

Increasing the connectivity of pedestrian and bicycle networks in Eugene is also likely to increase residents' connection to transit, the benefits of which are discussed in Objective 5.

As with several other objectives, urban design will play an important role in how well new bicycle and pedestrian infrastructure investments will support increased physical activity. See page 27 for information about "The Community Guide to Preventive Service" – a review of evidence-based urban design features that have been proven to support physical activity.

Even as more climate change mitigation and adaptation strategies are implemented locally and across the world, temperature increases already underway will still affect pollution levels and water levels. Therefore, investments in pedestrian and bicycle infrastructure should be carefully located to avoid likely areas of flooding and should be supported by landscaping and other features that may limit pollution exposure.

Priority Action 7: Create a "Complete Streets" policy that requires all new transportation projects and rehabilitation projects to incorporate bicycles, pedestrians, and mass transit service.

Implementing a complete streets policy means that streets will be designed with all users – such as pedestrians, bicyclists, vehicles, public transit riders, children, older adults, and disabled people – in mind. Although there is no single standard set of criteria defining a complete street, many of them will share common elements, such as sidewalks, bike lanes, bus lanes, multiple crossing areas, and audible pedestrian signals.[148] Streets that are designed only for vehicles are often not friendly to other users and can limit the movement of vulnerable populations, such as children, older adults, and disabled persons.

Physical Activity

Benefits to health will be similar to those discussed for Priority Actions 5 and 6, but a complete streets policy is also likely to benefit vulnerable populations especially.

Vulnerable Populations

Children are most likely to have the opportunity for active transportation when going to and from school. However, parents report that traffic danger is the factor that mostly often prohibits their children from walking or biking to school; long distances is the second most common reason reported by parents.[149] Streets without sidewalks or with heavy traffic can be significant barriers to children's active transportation, leading children instead to ride a bus or get a ride from their parents, despite walkable or bikeable distances. Children that walk to school are more physically active overall compared to those who travel to school by car.[150] In Australia, parental concerns about walking and biking safety were negatively associated with 10-12 year old children walking or biking to nearby destinations.[151]

Collisions

As with physical activity, health benefits from reduced collisions will be similar to those discussed for Priority Actions 5 and 6, with extra benefits for vulnerable populations.

Vulnerable Populations

Parental concern about the safety of children as pedestrians is not unfounded; in 2007, 20% of children 9 years or younger and 15% of children 10-15 years who were killed in traffic collisions were pedestrians.[152] Further, children that report having difficulty with traffic (e.g., missing sidewalk/path, do not know when it's safe to cross, insensitive/unaware drivers) have a higher risk of collisions than those who do not report difficulties.[153]

Older adults also share an excess burden of pedestrian-related collision fatalities. Adults aged 70 years and older accounted for 16% of all pedestrian fatalities. For pedestrians 70 years and older, the fatality rate is higher than any other age group: 2.66 per 100,000 population.[154] Designing streets with all users in mind will positively impact older adults, since they have different needs compared to other groups.

Risk of pedestrian-vehicle collisions are higher for older adults at crosswalks that are marked but do not include a traffic signal or stop sign than those that have a signal or sign.[155] Older adults in

Connecticut who had difficulty crossing the street reported that they had insufficient time to cross and difficulty with right-turning vehicles. In addition, less than 1% of older adults 72 years and older had a walking speed of at least 4 feet/second, the speed usually used to determine crossing times at intersections.[156] Older adults may take longer to cross streets; therefore very wide streets are less accessible and may not provide enough crossing time. Often, public transit stops do not provide a place to rest while waiting.

Not having an accessible built environment can limit the mobility of older adults and confine many of them to their homes. Focus groups conducted in Portland, Oregon indicated that traffic and pedestrian infrastructure and neighborhood attractiveness influenced the physical activity of older adults.[157] Slow traffic and good pedestrian infrastructure were important for older adults to feel walking was a safe activity in their neighborhoods.

Even with pedestrian infrastructure provided, the streets may still not be accessible for people with disabilities. People with physical disabilities have been found to be more likely to participate in leisure time physical activity if they live in areas with features that support active living, including activity-friendliness (e.g., street connectivity, park benches, and walking paths), density of destinations, and safety.[158] However, even when neighborhoods are accessible for the general population, there might still be barriers for people with visual or motor impairments. Disabled populations have reported problematic sidewalk pavement and puddles or poor drainage as barriers to physical activity in their otherwise accessible environment.[159]

Air Pollution

Here again, Priority Action 7's air pollution-related health benefits will be similar to those of Priority Actions 5 and 6.

Objective 5: Increase the supply of frequent, reliable, integrated and convenient public transit

Priority Action 8: Diversify funding sources for Lane Transit District (LTD) to increase the long-term reliability of service.

a. *Partner with Springfield, Lane County, LTD, and businesses to develop strategies for providing mass transit for the Eugene community.*

Priority Action 9: Align City of Eugene Transportation System Plan and LTD Long Range Transit Plan to integrate bus routes into the broader alternative transportation system.

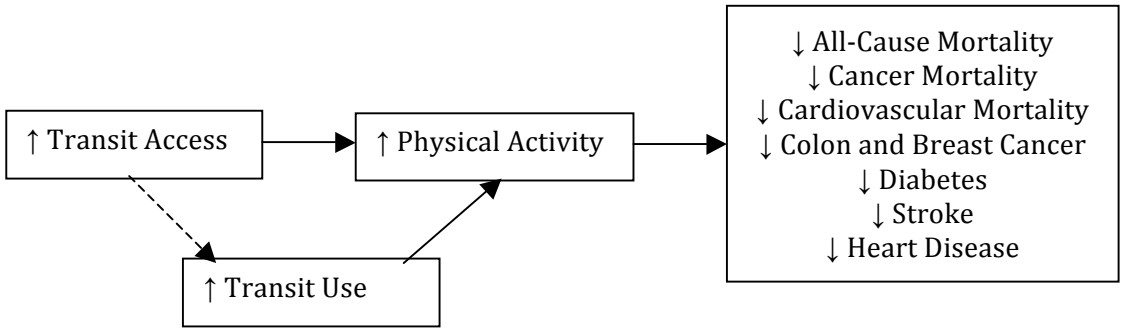
a. *Partner with LTD to help inform service changes and improvements.*
b. *Create special setbacks along future Bus Rapid Transit (BRT) or other mass transit corridors to accommodate future right-of-way expansion.*
c. *Work with LTD in developing the Long Range Transit Plan to determine the role of mass transit in accomplishing greenhouse gas emission reduction goals.*

Policy Action 10: Invest in transit infrastructure that meets future access and mobility needs while consuming less fossil fuel. Recommended actions include:

a. *Maximize electrification of the regional transportation system.*
b. *Increase use of hybrid vehicles, including buses and other heavy vehicles.*

In Eugene, data from 2006-2008 showed that only 6.8% of workers 16 years and older used public transit to commute to work (US Census Bureau, 2006-2008). On average in 2008, each resident of the Eugene metropolitan area used public transit 43 times per year.[160] Increasing the number of Eugene residents that use public transit can have a positive impact on health. **Figure 4** shows the relationship between public transit and health and is discussed in detail below.

Figure 4: Pathway Between Transit Access and Health



Physical Activity

As mentioned earlier in the "Physical Activity" portion of the Objective 1 analysis, transit use is associated with walking, often enough to meet public health recommendations for physical

activity.[161] [162] [163] [164] [165] [166] In a study examining individuals' body mass index (BMI)[xi] and physical activity before and after the completion of a light rail transit (LRT) system in Charlotte, NC, researchers found that those using the LRT to commute to work experienced, on average, a 1.18 decline in BMI. LRT commuters also reduced their odds of becoming obese over time by 81%.[167]

Increasing access to public transit may not be enough for the community to realize the most health benefits. Individual perception of transit access often does not correspond with measured objective access; simply increasing public transit access to Eugene neighborhoods will not increase physical activity if the perception of low access remains. If residents believe that public transit is not an option because it is not "accessible," they will not use the services provided. Positive perception of good transit access has also been found to be directly associated with physical activity.[168] [169] [170] [171] [172]

In 2002, 88% of households in the Eugene metropolitan area lived within ¼ mile of a public transit stop,[173] but a low proportion of the Eugene population takes advantage of public transit. The relatively low use of public transit could be related to residents perceiving they have little access to public transit or it could reflect infrequent, less dependable service that is less useful for residents to use, regardless of their proximity to a transit stop.

Vulnerable Populations

Public transit can be very important for vulnerable populations, such as older adults, children, low-income residents, and people with disabilities. In general, these groups are less independent and have limited individual transportation options. Older adults may feel unsafe driving at certain times of the day, or they may no longer operate a vehicle. Children are restricted to receiving rides from others or using active forms of transportation to reach destinations of interest. Low-income residents may not have the resources to pay for a personal vehicle and the costs associated with individual driving, and people with disabilities are more likely to be restricted in their use of personal vehicles as well. All of these groups would benefit from increased access to public transit and improved transit service; these changes would provide them with more options for traveling within and remaining connected to their neighborhood and community.

Collisions

Compared to driving, taking transit is generally safer.[174] Nationally, "the fatality rate (standardized by passenger miles) for bus riders in 2003-2005 was only 2.8% of the fatality rate for automobile drivers".[175] However, non-collision injuries on transit can have important health effects and are discussed in more detail in "Other Considerations."

Air Pollution

See Objective 8 for a discussion of the health benefits of electric, hybrid, and alternative fuel vehicles.

[xi] Body mass index is a measure of weight that takes a person's height into account. BMI is calculated by dividing a person's weight in kilograms by his or her height in meters squared. Obesity is defined as a BMI of 30 or greater, and overweight is defined as 27.3 or 27.8 for women and men, respectively.

Other Considerations

For many households, increased reliability of transit service would also decrease transportation expenditures, as more trips are made convenient via bus. As less of the household budget is spent on transportation, these households may experience less stress and have more resources to meet their daily needs.

Non-collision injuries and fatalities are more prevalent with transit use than with other modes. Injuries are most likely to occur during boarding or when the bus accelerates or decelerates.[176]

Vulnerable Populations

A recent analysis of bus collisions using data from Portland, OR, found "a positive association between lift usage and the expected frequency of non-collision incidents, suggesting that customers with disabilities face a relatively greater safety risk".[177] Improvements in lift mechanisms and securement devices should be considered in order to limit the risk of injury to vulnerable populations.

Objective 6: Expand outreach, marketing and education regarding climate-friendly transportation alternatives

Priority Action 11: Increase promotion of bicycling, walking, mass transit, car-pooling, telecommuting, high-occupancy vehicles, and emergency ride home as attractive alternatives to driving in order to increase the mode share of alternatives to the single-occupant vehicle. Partner with Point 2 Point Solutions, Lane Transit District, Greater Eugene Area RiderS (GEARS), BikeLane Coalition, local businesses, the City of Eugene Smart Trips program, Safe Routes to School, Lane Coalition for Healthy Active Youth, Lane County Public Health, Climate Masters at Home™, and others.

Priority Action 12: Increase the community's understanding of fuel-efficient driving techniques.

Changes made to Eugene neighborhoods, such as designs that support the creation of 20-minute neighborhoods and increased access to public transit, will be valuable alterations to the community and benefit the health of Eugene residents. However, as mentioned in the discussion of Objective 5, it is possible that making these changes alone will not be enough to encourage Eugene residents to use the new amenities or services. It might be necessary to promote changes, such as new bicycle routes or increased public transit service, to inform Eugene residents of the available transportation options beyond the personal vehicle.

Physical Activity

Often, policy changes that are supported by programs and promotion of these changes can increase the use of alternative forms of transportation. A project to increase active transportation in Jackson, Michigan used active living promotion and programs. Promotion techniques included a website and quarterly newsletter, use of billboards, press releases, and events like "Smart Commute Day" and "Walk to School Day." The project generated more walking and biking trips and increased the number of students walking to school.[178] Another promotion project in Omaha using marketing campaigns, community-wide media campaigns, and a social marketing toolkit for businesses resulted in more residents having explored parts of Omaha on foot as well as an increase in participation in the Bicycle Commuter Challenge.[179]

A Bike to Work Week was initiated in Victoria, British Columbia in 1995. Despite having about 500 participants, the event failed to motivate potential bicyclists who were the true target of the event. Organizers worked on recruiting bicycling team captains from individual workplaces to help promote bicycling. The result was that Bike to Work Week grew from 1075 participants in 1998 to 6446 participants in 2008.[180]

A UK intervention promoting active transportation to work titled "Walk In to Work Out" was successful in increasing the amount of commute-related walking but not in increasing the amount of cycling. The intervention included a booklet with information on choosing routes, maintaining personal safety, shower and safe cycle storage information, and useful contacts. Additionally, an activity diary, workplace map, distances from local stations, local cycle retailers and outdoor shops, contacts for relevant organizations, local maps, and reflective safety accessories were included. Participants increased their amount of walking through various means, like getting off the bus a stop early, using public transit more, and parking further away from destinations.[181]

In 2007, the Oregon Department of Transportation used individual marketing to promote environmentally friendly modes of travel in Eugene. Households received tote bags containing information materials, such as bus schedules specific to each household. An increase in walking, bicycling, and public transit was seen, and a simultaneous decrease was seen in car trips. Mobility did not decrease as a result of the transportation mode shift; cars were used for fewer trips, while active transportation trips increased.[182]

A review of four interventions that targeted travel behavior, in a motivated subsample of the population or by using tailored information, showed that the interventions were successful in increasing the amount of active commuting. For example, the "Walk In to Walk Out" materials were used in Scotland and resulted in more time spent walking to work among participants. Another program called "TravelSmart" targeted households interested in changing their behavior and provided tailored resources. Results from England and Australia showed that households shifted between 3.6%-5.5% of trips towards active transportation.[183]

It remains to be seen whether the behavior changes resulting from promotion are long lasting. However, if changes are made but not promoted to residents in Eugene, it is unlikely that many of the changes would be discovered on their own.

Other Considerations

Fuel-efficient driving techniques vary with technology. Currently, electric and hybrid vehicles are most efficient at slower speeds, while gas cars peak around 35-45 mph. As a result, the promotion of electric and hybrid vehicles (along with fuel-efficient driving techniques) may benefit motor vehicle, bicycle, and pedestrian traffic patterns by reducing overall vehicle traffic speeds, and thereby reducing fatalities.

Programs such as bike sharing, and facilities such as covered bike parking and end-of-trip showers will also make it easier for individuals to use bicycles for commuting and other trips. While some end-of-trip facilities will make it more convenient for individuals to continue to use active transportation methods even in inclement weather, education programs about how to safely and comfortably bike or walk in such weather should support these facilities.

Objective 7: Ensure maximum efficiency in current and future freight systems

Priority Action 13: Plan for efficient freight transportation that minimizes greenhouse gas emissions and fossil fuel consumption, and:

a. *Connects multiple modes (train, truck, van, car, bicycle);*
b. *Accommodates regional (upper Willamette Valley) commercial, industrial and agricultural freight needs; and*
c. *Facilitates efficient local deliveries.*

Freight movement in the United States, whether by trucks, trains, or ships, is largely powered by diesel fuel, a major source of particulate matter and nitrogen oxides, which combine with volatile organic compounds to form ozone.[184] Over the past 10 years, Lane County has exceeded the NAAQS threshold for particulate matter ($PM_{2.5}$) more than other counties in Oregon. Due to the land patterns in Lane County, the air pollutants frequently remain trapped in the Willamette Valley, especially in colder months due to more frequent temperature inversions.[185] Since the land topography traps pollutants in the valley, it becomes even more important to control the emissions from freight diesel in Eugene.

Table 13: Percentage of Monitored Days and Number of Person-days (in Thousands) During Which the Measured PM (2.5) Concentration Exceeded the NAAQS of 35 mcg/m³ in Lane County

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Percent	5.0	7.9	9.6	7.1	5.5	4.7	10.1	4.8	7.4
Person-days	5792	9381	11359	8502	6598	5632	8028	2027	3092

Source: http://www.oregon.gov/DHS/ph/epht/docs/airrep.pdf

The air quality of the Eugene-Springfield area differs significantly from the measurements for all of Lane County, though. In 2009, the Environmental Protection Agency designated Oakridge a non-attainment area for the national standards for 24-hour $PM_{2.5}$.[186] Because Oakridge's $PM_{2.5}$ concentrations are included in the general county figures in **Table 13**, the table is valuable primarily as a comparison to Eugene (see **Table 14** for Eugene-Springfield measurements).

Table 14: Percentage of Monitored Days and Number of Person-days (in Thousands) During Which the Measured PM (2.5) Concentration Exceeded the NAAQS of 35 mcg/m³ or Measured Ozone Concentration Exceeded the 2008 NAAQS of 75 ppb Willamette Valley Portion of Lane County*

		2001	2002	2003	2004	2005	2006	2007	2008	2009
Particulate Matter	Percent	1.9	1.9	0.8	0.8	2.5	1.6	2.5	0.3	3.0
	Person-days	2195	2209	950	962	2609	1959	2968	331	3663
Ozone	Percent	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
	Person-days	0	0	988	0	0	0	0	0	0

*Includes Eugene-Springfield area.
Source: www.lrapa.org [Lane Regional Air Protection Agency]

Air Pollution

Currently, Eugene meets the Environmental Protection Agency standards for particulate matter$_{2.5}$ and ozone. Using particulate matter$_{2.5}$, ozone, and carbon monoxide data, in 2009 the Eugene-Springfield area had eight days when the air quality was unhealthy for sensitive populations and

one day when the air quality was unhealthy for the general public. The current goal is to lower diesel emissions to 50% of 2010 levels by 2030, partially through improvements in freight efficiency. This will have a profound impact on the health of Eugene residents.

Ground-level ozone is also known as smog and can cause respiratory irritation, compromised respiratory function, aggravated asthma, increased susceptibility to respiratory illness (e.g., bronchitis and pneumonia), and permanent lung damage with prolonged exposure.

A study conducted by Bell and Dominici found that a 10 ppb increase in daily average ozone was associated with a 0.52% increase in mortality.[187] If current freight ozone levels are reduced, one can expect a corresponding increase in life expectancy.

Particulate matter causes respiratory health effects similar to those caused by ozone, and particulate matter also contributes to irregular heartbeat, nonfatal heart attacks, and premature death for people with heart or lung disease. Particles under 10 μm in diameter are the most problematic, because they can enter lung tissue and possibly even the blood stream.[188]

A recent analysis found that a decrease of 10 $\mu g/m^3$ of $PM_{2.5}$ was associated with an increase in life expectancy by 0.61 years. If current freight $PM_{2.5}$ levels are reduced, one can expect a corresponding increase in life expectancy.[189]

Vulnerable Populations

Populations at highest risk for the adverse effects of ozone include children, adults with lung diseases (e.g., asthma), and those working or spending leisure time outdoors.[190] Particulate matter and Ozone exposure is related to the development of asthma in children as well as children's hospitalization for asthma and other respiratory emergencies.[191] Exposure to particulate matter has been linked to increases in pre-term birth and increases in infant mortality.[192] [193]

Objective 8: Increase the use of low-carbon vehicles and fuels to improve overall fuel-efficiency and reduce vulnerability to fluctuating oil prices.

Priority Action 14: Accelerate the transition to plug-in hybrids and electric vehicles. Partner with Lane County, EWEB, auto retailers, electrical contractors, UO, LCC, and others.

a. *Support the installation of a network of electric car charging stations.*
b. *Require installation of electric car charging stations in new multifamily housing.*
c. *Use guidance provided by the University of Oregon Electric Vehicle strategy.*

Altering the built environment (by, for example, creating 20-minute neighborhoods or enhancing the bicycle infrastructure) can help reduce air pollution and time spent driving. Changing the vehicles that people drive can also reduce air pollution, by replacing gasoline-powered vehicles (with their attendant emissions) with electric vehicles. Installing electric car charging stations could increase the feasibility of using electric vehicles in Eugene, and an increased use could have positive effects on the health of residents.

The potential for plug-in hybrid electric vehicles and battery electric vehicles to achieve large-scale greenhouse gas (GHG) emission reductions is highly dependent on the energy source of electricity production. For example, battery electric vehicles eliminate local air pollution, but this pollution may just be displaced to another area. Therefore, it's important to consider simultaneous policies that encourage charging with low-carbon electricity. For example, although 3% of the resources used by the Eugene Water and Electric Board to supply electricity come from coal, 24% of the resources used by Portland General Electric to supply electricity come from coal.[194] [195]

Although the power source is important, often the source of electricity is a cleaner source than gasoline. Therefore, compared with conventional vehicles, plug-in electric hybrid vehicles can reduce GHG emissions by 32%, but the reductions are small compared with traditional hybrid vehicles.[196][xii] A study focusing on carbon dioxide (CO_2) emissions alone found that plug-in electric hybrid vehicles have lower emission rates than conventional vehicles and hybrid electric vehicles. Replacing inefficient coal plants with facilities that have lower emissions of CO_2 would also result in CO_2 reduction.[197]

Assuming a 40% market penetration and 50% of new car sales of plug-in hybrid electric vehicles by 2030 in the United States, a report compiled by Electric Power Research Institute showed that plug-in hybrid electric vehicles would lead to small improvements in air quality. When considering the electric and vehicle emissions together, volatile organic compounds (VOC), nitrogen oxides (NOx), and sulfur dioxides (SO_2) all decrease. While ozone also decreased for most areas in the country, 1% of the population was expected to see an increase in ozone levels. Particulate matter (PM) levels will increase, primarily through increased coal generation that was assumed for the electric sector. However, secondary PM is expected to decrease due to lower VOC and NOx emissions.[198]

[xii] A hybrid electric vehicle uses an internal combustion engine and an electric propulsion system. The electric system can be recharged through the combustion engine or through regenerative breaking technology. A plug-in hybrid electric vehicle's electric system can be recharged by plugging into the electric grid.

Air Pollution

It is likely that the air quality will improve in Eugene due to the use of plug-in electric hybrid vehicles, although further research should be conducted to ensure that pollution is not displaced to the areas with the power source.

Other Considerations

Although the increased use of plug-in hybrid electric vehicles and battery electric vehicles is likely to have health benefits in the Eugene area, adoption of these vehicles may be cost-prohibitive for many households. Programs to assist low-income households may be necessary to make it possible for these residents to consider transitioning to plug-in hybrid electric vehicles and battery electric vehicles.

Priority Action 15: Conduct research to understand what role biofuels can play in decreasing Eugene's vulnerability to energy markets. Work with partners at LTD, the Oregon Department of Energy, etc.

a. *Complete research by 2013 so that outcomes can inform the next CEAP.*

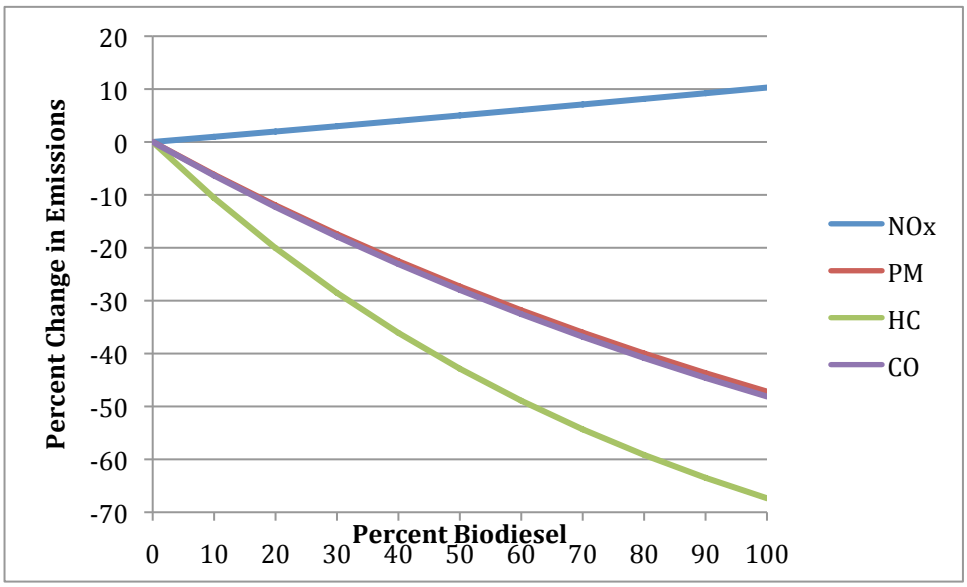
As natural resources become more difficult to obtain, ensuring that Eugene has renewable options for fuel sources is important. Biodiesel and ethanol are both viable options as renewable fuels and have the potential to impact the health of Eugene residents as well as decrease the dependency on foreign resources.

Biodiesel

From mobile sources, diesel-powered vehicles and equipment are important contributors to particulate matter and nitrogen oxides emissions.[199] [200] Biodiesel can be locally produced in Oregon from renewable sources, like oilseed crops, animal fats, and waste cooking oils.[201] Further, biodiesel has the potential to lower emissions when compared with conventional diesel.

A review conducted by the EPA found that particulate matter (PM) dropped by almost half when using 100% biodiesel (B100) and by 12% when using a diesel mix with 20% biodiesel (B20) (**Figure 5**). However, nitrogen oxides (NOx) increased by 2-4% with B20 and by 10% with B100.[202]

Figure 5: Change in Emissions from 20% Biodiesel Blend or 100% Biodiesel when Compared with Conventional Diesel.



NOx = Nitrogen oxides
PM = particulate matter
HC = hydrocarbons
CO = carbon monoxide
Source: US EPA, 2002

Results published after the EPA study (2002) showed that NOx change for B20 ranged from -10% to +6% and the average change was -0.6% (+/-2.0% 95% CI). NOx emissions appear to vary widely depending on the engine manufacturer and design. PM decreased by 14.1% in recent studies.[203] B20 likely has a negligible impact on NOx levels. However, the impact on PM, carbon dioxide (CO),

and total hydrocarbon (THC) is larger and B20 shows consistent reductions in these emissions for essentially all engines tested.[204]

Submicron particulates (particulates less than 1 um in diameter) are important to consider for health because smaller particulates can lodge deeper in lung tissue. Although both diesel and biodiesel were shown to emit the same size of particles, it has been shown that in comparison with petroleum-based diesel, biodiesel can reduce total number concentration of submicron particles by 24-42%.[205]

Particulate matter leads to respiratory problems, like irritation and coughing, compromises respiratory function, aggravates asthma, and leads to bronchitis, irregular heartbeat, nonfatal heart attacks, and premature death for people with heart or lung disease.[206] In addition, particulate matter has been associated with cardiopulmonary mortality,[207] [208] and fine particulate matter has been linked to all-cause and lung cancer mortality.[209] Decreases in fine particulate matter are associated with increased life expectancy[210] and decreases in chronic coughing and phlegm, wheezing, and dyspnea.[211] Decreasing the exposure of Eugene residents to particulate matter would positively impact their health through decreased respiratory problems.

Other Considerations

However, biodiesel is lower in energy concentration compared to conventional diesel. Animal-based biodiesel has 10.6% less energy content and plant-based biodiesel has 7.9% less energy content compared to conventional diesel. Energy content of fuel is a good predictor of relative fuel economy. Using biodiesel will reduce fuel economy, most likely within the ranges listed in **Table 15**.[212]

Table 15: Percent Reduction in Miles/Gallon

Fuel	Percent Reduction in Miles/Gallon
20% Biodiesel	0.9-2.1
100% Biodiesel	4.6-10.6

Source: US EPA, 2002

Ethanol

Ethanol or ethanol-blend fuels are also alternative options to conventional petroleum gasoline. Replacing conventional gasoline with a blend of 85% ethanol by volume and 15% gasoline may reduce tailpipe emissions of carbon monoxide and nitrogen oxides but may increase hydrocarbon emissions.[213] Blends with less ethanol by volume (3, 6, and 9%) emit less carbon monoxide, hydrocarbons, and nitrogen oxides (**Table 16**).[214]

Table 16: Change in Emissions from 3, 6, 9, and 85% Ethanol Blend, Compared with Conventional Gasoline

Fuel	Percent Change from Conventional Gasoline			
	E3	E6	E9	E85
Carbon Monoxide	-42	-86	-83	-22
Nitrogen Oxides	-35	-86	-77	-8
Hydrocarbons	-79	-98	-90	+12

Source: Lin, Chang, & Hsieh, 2010 and Zhai, Frey, Rouphail, Concalves, & Farias, 2009

However, an analysis on carcinogens emitted from both gasoline and ethanol fuels cautioned against replacing gasoline completely with ethanol fuel. Ozone-related mortality, hospitalizations, and asthma-related emergency room visits were all expected to increase with the use of E85.[215]

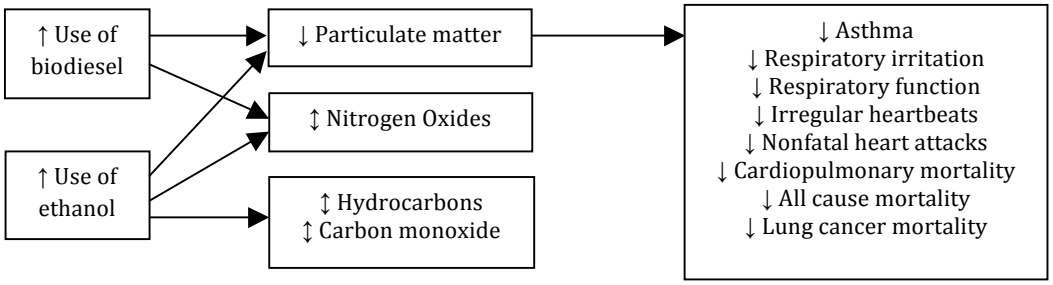
Ethanol-diesel blends offer another alternative to conventional diesel. Emissions tests with ethanol-diesel blends show fairly consistent results for reducing particulate matter emissions, although the impacts on carbon monoxide, nitrogen oxides, and total hydrocarbons are less conclusive and depend on the blends.[216] [217]

Vulnerable Populations

Low-income populations are more likely to live and go to school in places with higher traffic exposure. Lower-income neighborhoods have higher exposure to particulates than higher-income areas. Additionally, low-income neighborhoods with high particulate exposure were associated with an increased risk of death from non-accidental causes compared to high-income neighborhoods with low particulate exposure.[218] It is likely that low-income populations have higher exposure to diesel pollution in Eugene and will be more positively affected by any reductions in diesel pollution.

Overall, biodiesel is a promising alternative to petroleum diesel and may have positive impacts on the health of Eugene residents (**Figure 6**), primarily through the reduction of particulate matter. Ethanol fuel is more controversial but would likely lower levels of particulate matter as well.

Figure 6: Pathway Between Increased Use of Biofuels and Health



Other Considerations

Although the impact on air pollution is important, especially for populations that are exposed to high amounts of diesel exhaust (such as people living by freight corridors or near transit centers), it is also important to consider the other impacts of using fuels produced from food crops. If the entire corn and soybean crops in the US were devoted to the production of biofuels, their use would offset 12% of the gasoline and 6% of the diesel demand. However, these crops are major contributors to the food supply in the United States, and it is unlikely that the food supply would be unaffected if a large amount of these crops were devoted to producing biofuels.[219] Using an alternative to produce biofuels, such as agricultural residue like corn stover, might be a better option, since it will have less of an impact on the food supply.

Further considerations include whether the resources used to produce the materials for biofuels create more environmental problems, such as increased use of pesticides and fertilizers to grow the

crops needed for fuel production[220] and which biofuel is the most cost-effective to reduce emissions in Oregon.[221]

RECOMMENDATIONS

These recommendations suggest strategies to best improve the health of Eugene residents while decreasing greenhouse gas emissions in Eugene and the surrounding area.

Recommendation #1: Approve the Transportation and Land Use section of the Climate and Energy Action Plan in order to improve the health of Eugene residents.

This analysis shows that the Transportation and Land Use objectives in the draft CEAP have benefits for the public's health, and several of the objectives and priority actions are consistent with the Centers for Disease Control and Prevention's recommendations for improving health through transportation policy.[222] Key benefits include improved air quality, increased physical activity, and reduced injuries. An estimate of the magnitude of these benefits was outside of the scope of this study. However, these positive benefits, together, are likely to significantly increase lifespans and reduce healthcare costs in Eugene and the surrounding region.

Recommendation #2: To ensure maximum benefits to human health, make sure that active forms of transportation are measurably increased, while meeting greenhouse gas reduction goals.

Although all of the recommendations in the CEAP are likely to improve health, they are not all equal in their benefits. In a study modeling greenhouse gas emission reduction strategies, researchers found that a scenario focused on increased active transportation showed greater health benefits (nearly five times the estimated increase in disability-adjusted life years) than a scenario that focused on lower-carbon-emission vehicles. However, a combination of both strategies showed an even greater positive health impact than either strategy alone.[223] In this study, the active transportation scenario that was modeled included high levels of walking and bicycling for transport (similar to those seen in Copenhagen or Amsterdam, for instance).

The 2007 Regional Transportation Plan for the Lane metropolitan area projected what proportion of trips would, under the plan, be completed by different modes in 2031. The plan indicates that 16.1% of all trips in 2031 would be non-auto trips; 9.76% of trips would be completed by walking, while 3.87% of trips and 2.48% of trips would be complete by biking and public transit, respectively.[224] While these figures are high for Oregon, they are low when compared to the active transportation scenario mentioned above. For example, in 2002, 34% of commute trips and about 20% of all trips in Copenhagen were made by bike.[225]

In order to ensure that reduced greenhouse gas emissions also mean increased active transportation, specific goals for walking, biking and public transit rates should be set to correlate with greenhouse gas goals, and all local, regional and state plans should be consistent with these active transportation goals.

Recommendation #3: Promote urban density while seeking strategies to reduce the potential negative impacts of density.

Increased density has a critical place in reducing greenhouse gas emissions and promoting more vibrant cities. Increased density supports physical activity and promotes better access to healthy food and other goods and services. In the region overall, the total air pollutants are reduced, thereby decreasing respiratory ailments.

However, density also has the potential to increase minor vehicle collisions and to increase bicycle and pedestrian collisions. Increased density may also increase noise, which can lead to stress for residents. Increased density may contribute to pricing low-income populations and communities of color out of the urban center into suburbs, where they are more dependent on sedentary forms of transportation and lack access to healthy food and other goods and services.

Therefore, strategies for increased density should be combined with diverse strategies to increase livability within dense urban areas. Increased investment in infrastructure and safety improvements for bicyclists and pedestrians should accompany the development of increased density, in order to prevent an increase in collisions. Urban design features, such as clearly marked and raised pedestrian paths, improved lighting and landscaping, specialized bike and pedestrian signals, and auto-free zones, can promote physical activity and improve safety even in high-density environments. Integrating transportation and land use planning processes to increase access to parkland (and other health-promoting destinations) may offset some of the stress of living in a dense area by making it easier for residents to access greenspace and physical activity opportunities.

Polices that promote increased density and the development of 20-minute neighborhoods must be accompanied by strategies to ensure that ample affordable housing options will be available in neighborhoods that support active transportation.

These strategies together can help ensure that the negative health impacts of density are avoided or minimized.

Recommendation #4: Invest in a safer and more efficient pedestrian and bicycle infrastructure.

Eugene already has a high rate of bicycle use and walking for transportation, compared to Oregon in general. However, both of these modes are likely to continue to grow if residents perceive bicycling and walking as safer and easier. In order to encourage a higher proportion of trips to be made by walking or by bicycle, Eugene should invest in the development of complete streets that include evidence-based design features and safety improvements.

Investments in the creation of strong pedestrian and bicycle route connectivity will also have a large impact on walking and cycling rates. Connectivity has been shown to increase walking and biking and is an important component of the 20-minute neighborhood concept. Both bicycling and walking have a broad range of health benefits, while also reducing greenhouse gas emissions.

Recommendation #5: Ensure investments in public transit access benefit low-income communities and other vulnerable populations.

Vulnerable populations including low-income, youth, elderly, disabled and people of color often depend more heavily on public transit for commuting and for buying necessary goods and services. It is important that public transit investments should seek to improve overall access to public transit, while reducing greenhouse gas emissions. Attention should be paid not just to how low-income neighborhoods and other communities can connect to worksites, but also to full-service grocery stores, childcare facilities, schools and parkland.

Recommendation #6: Integrate health impact assessment practice into current land use and transportation planning at the state and local level.

A growing body of literature, described in this report and others, shows that transportation and land use planning practices have broad and significant impacts on human health. However, these impacts are not often considered in the planning process. In order to better improve health in transportation planning, it will be necessary to assess the impacts of all transportation and land use plans on health, create recommendations to improve health, implement healthier planning options, and evaluate the health outcomes from previous plans. In the assessment stage, health outcomes can be assessed through formal stand-alone HIAs (as conducted for example for the Humboldt County Comprehensive Plan[226]), or for smaller projects, rapid HIAs or health outcomes checklists can be used. The Healthy Development Measurement Tool[227] can be a useful tool for understanding key health outcomes without necessarily doing a full HIA.

Recommendation #7: Develop a system to track injuries and fatalities by transportation mode, to evaluate plan implementation and systematically improve bicycle and pedestrian outcomes.

Injury and fatality data is currently only available for vehicle collisions (including collisions with bicycles and pedestrians). Without an accurate measurement of all bicycle and pedestrian injuries and fatalities (in relation to the number of trips that each of these modes generate), it is difficult to understand how existing conditions impact safety.

Appendix

Demographic Data

Median Household Income, Percent Households, 2006-2008:

Inco me	Eugene	Salem	Portland	Oregon
Less than $10,000	12.1%	7.5%	8.5%	7.0%
$10,000 to $14,999	6.3%	6.7%	6.1%	5.6%
$15,000 to $24,999	12.8%	13.1%	10.8%	11.1%
$25,000 to $34,999	11.1%	13.3%	11.2%	11.4%
$35,000 to $49,999	14.3%	15.3%	14.3%	15.0%
$50,000 to $74,999	18.5%	20.3%	18.4%	19.9%
$75,000 to $99,999	10.5%	10.4%	11.7%	12.4%
$100,000 to $149,999	9.1%	9.6%	11.0%	11.1%
$150,000 to $199,999	2.7%	2.7%	4.2%	3.4%
$200,000 or more	2.6%	1.2%	3.9%	3.0%

Data from the American Community Survey 3 year estimates, 2006-2008.

Educational Attainment for Percent Population 25 Years and Over, 2006-2008:

Educational Attainment	Eugene	Salem	Portland	Oregon
Less than 9th grade	3.1	6.6	4.4	4.5
9th to 12th grade, no diploma	4.9	8.7	6.4	7.4
High school graduate (includes equivalency)	20.0	26.2	20.6	26.5
Some college, no degree	24.5	24.3	22.9	25.6
Associate's degree	8.1	9.2	6.3	8.0
Bachelor's degree	22.5	16.0	24.1	17.8
Graduate or professional degree	17.0	9.0	15.5	10.1
Percent high school graduate or higher	92.1	84.7	89.4	88.0
Percent bachelor's degree or higher	39.5	25.0	39.6	27.9

Data from the American Community Survey 3 year estimates, 2006-2008

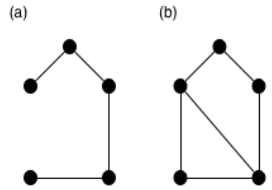
Street Connectivity

Street connectivity can be quantified in a number of ways, including the calculation of Alpha and Gamma indices. The Alpha Index(α) represents the ratio of the actual number of complete loops to the maximum number of possible loops with higher numbers representing a higher level of complexity and connectivity. The Gamma Index (γ) represents the ratio of actual number of street segments to maximum possible, with higher numbers representing areas with more gridded street patterns and lower numbers representing areas with more cul-de-sacs. Both indices can range from 0 to 1, where 0 represents poor connectivity and 1 represents a well-connected street network.

Alpha Connectivity

	Edges	Vertices	α
a	4	5	0
b	6	5	0.4

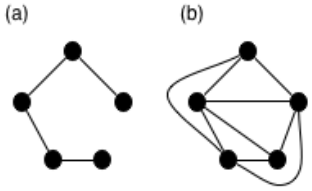
α = (edges-vertices+1)/(2*vertices – 5)



Gamma Connectivity

	Edges	Vertices	γ
a	4	5	0.44
b	9	5	1.0

γ = edges/(3*(vertices-2))



The Lane County census tracts range from an Alpha value of 0.03 (very low connectivity) to 0.39 (higher connectivity). Gamma values range from 0.35 to 0.60 (data from the RAND Center for Population Health and Health Disparities).[xiii]

[xiii] This research used data from the RAND Center for Population Health and Health Disparities, which is funded by grant 1-P50-ES012383 from the National Institute of Environmental Health Sciences. For further information on the CPHHD, go to http://www.rand.org/health/centers/pophealth/index.html.

References

[1] Centers for Disease Control and Prevention (CDC)(2010). Health impact assessment. Retrieved July 19, 2010 from: http://www.cdc.gov/healthyplaces/hia.htm.

[2] Longstreth, J. (1999). Public health consequences of global climate change in the United States: Some regions may suffer disproportionately. *Environmental Health Perspectives*, 107(1S), 169-179.

[3] Epstein, P.R. (2005). Climate change and human health. *New England Journal of Medicine*, 353, 1433-1436.

[4] United States Environmental Protection Agency (2010). Climate change: Health and environmental effects. Retrieved July 26, 2010 from: http://www.epa.gov/climatechange/effects/health.html.

[5] McMichael, A.J., Campbell-Lendrum, D.H., Corvalán, C.F., Ebi, K.L., Githeko, A.K., Scheraga, J.D., and Woodward, A., editors (2003). Climate Change and Human Health: Risks and Responses. Prepared for the World Health Organization. Retrieved July 26, 2010 from: http://www.who.int/globalchange/publications/cchhbook/en/.

[6] Githeko, A.K., Lindsay, S.W., Confalonieri, U.E., and Patz, J.A. (2000). Climate change and vector-borne diseases: a regional analysis. *Bulletin of the World Health Organization*, 78(9).

[7] Longstreth, 1999.

[8] Ibid.

[9] Ramin, R. and Svoboda, T. (2009). Health of the homeless and climate change. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, 86(4), 654-663.

[10] Pope, C.A., Burnett, R.T., Thun, M.J., Calle, E.E., Krewski, D., Ito, K., and Thurston, G.D. (2002). Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *Journal of the American Medical Association*, 287, 1132-1141.

[11] Filleul, L., Rondeau, V., Vandentorren, S., Le Moual, N., Cantagrel, A., Annesi-Mausano, I., Charpin, D., Declercq, C., Neukirch, F., Paris, C., Vervloet, D., Brochard, P., Tessier, J.F., Kauffmann, F., and Baldi, I. (2005). Twenty-five year mortality and air pollution: Results from the French PAARC survey. *Occupational and Environmental Medicine,* 62, 453-460.

[12] Lee, I.M. (2003). Physical activity and cancer prevention: Data from epidemiologic studies. *Medical Science and Sports Exercise*, 35(11), 1823-1827.

[13] Oguma, Y. and Shinoda-Tagawa, T. (2004). Physical activity decreases cardiovascular disease risk in women: review and meta-analysis. *American Journal of Preventive Medicine*, 26(5), 407-418.

[14] Blair, S.N., Kohl, H.W., Paffenbarger, R.S., Clark, D.G., Cooper, K.H., and Gibbons, L.W. (1989). Physical fitness and all-cause mortality: A prospective study of healthy men and women. *Journal of the American Medical Association*, 262(17), 2395-2401.

[15] Gregg, E.W., Gerzoff, R.B., Caspersen, C.J., Williamson, D.F., and Narayan, K.M. (2003). Relationship of walking to mortality among US adults with diabetes. *Archives of Internal Medicine*, 163(12), 1440-1447.

[16] Hu, F.B., Willett, W.C., Li, T., Stampfer, M.J., Colditz, G.A., and Manson, J.E. (2004). Adiposity as compared with physical activity in predicting mortality among women. *New England Journal of Medicine*, 351(26), 2694-2703.

[17] Myers, J., Kaykha, A., George, S., Abella, J., Zaheer, N., Lear, S., Yamazaki, T., and Froelicher, V. (2004). Fitness versus physical activity patterns in predicting mortality in men. *American Journal of Medicine*, 117(12), 912-918.

[18] Woodcock, J., Edwards, P., Tonne, C., Armstrong, B.G., Ashiru, O., Banister, D., Beevers, S., Chalabi, Z., Chowdhury, Z., Cohen, A., Franco, O.H., Haines, A., Hickman, R., Lindsay, G., Mittal, I., Mohan, D., Tiwari, G., Woodward, A., and Roberts, I. (2009). Public health benefits of strategies to reduce greenhouse gas emissions: urban land transport. *Lancet*, 374, 1930-1943.

[19] Niemi, E. and ECONorthwest Staff (2009). An Overview of Potential Economic Costs to Oregon of a Business-As-Usual Approach to Climate Change. Retrieved July 19, 2010 from: http://climlead.uoregon.edu/publications/climate-economics.

[20] California EPA, Air Resources Board (2010). Working Draft Cap-and-Trade HIA Framework. Retrieved June 16, 2010 from: http://www.arb.ca.gov/cc/ab32publichealth/meetings/ 012710/hia_framework.pdf.

[21] Ibid.

[22] California Climate Action Team, Land Use and Infrastructure Working Group (2010). Near Implementation Plan Strategy #1: Develop and Disseminate Information and Guidance. Retrieved June 10, 2010 from: http://www.climatechange.ca.gov/climate_action_team/reports/catnip/ land_use/Land%2520Use%25201%2520-%2520Data%2520Dissemination%2520CATNIP.pdf.

[23] Upstream Public Health (2009). Health Impact Assessment on Policies to Reduce Vehicle Miles Traveled in Oregon Metropolitan Areas. Retrieved on July 10th, 2010 from: http://www.upstreampublichealth.org/newsroom?type=reports.

[24] Woodcock et al., 2009.

[25] Maryland Department of the Environment (2008). Maryland Climate Action Plan. Retrieved June 18, 2010 from: http://www.mde.state.md.us/Air/climatechange/legislation/index.asp.

[26] Chiu, K., Lei, Y., Zhang, Y., and Chen, D. (2007). Breathing Better: Linking Energy and GHG Reduction to Health Benefits in China. Woodrow Wilson International Center for Scholars China Environment Series. Retrieved June 16, 2010 from: http://www.epa.gov/ies/pdf/china_natl_assess/chiu_koehn_ellis_commentaries_ces9.pdf.

[27] Ibid.

[28] Population Research Center, College of Urban and Public Affairs Portland State University (PRC)(2009). Population Forecasts for Lane County, its Cities and Unincorporated Area 2008-2035. Retrieved July 21, 2010 from: http://www.lanecounty.org/Departments/PW/LMD/LandUse/Pages/population_forecasts.aspx.

[29] Ibid.

[30] United States Census Bureau (2008). American Community Survey 1-year estimates. Retrieved February 28, 2010 from: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId=&_lang=en&_ds_name=ACS_2008_1YR_G00_&ts=.

[31] United States Census Bureau (2006-2008). American Community Survey 3-year estimates. Retrieved February 28, 2010 from: http://factfinder.census.gov/servlet/DCGeoSelectServlet?ds_name=ACS_2008_3YR_G00_.

[32] Oregon Labor Market Information System (2010). Unemployment rates seasonally adjusted. Retrieved July 20, 2010 from: http://www.qualityinfo.org/olmisj/OlmisZine.

[33] Bureau of Labor Statistics, Department of Labor (2008). Labor force characteristics by race and ethnicity, 2008. Retrieved July 19, 2010 from: http://www.bls.gov/cps/race_ethnicity_2008.htm.

[34] Mobilizing Action Towards Community Health (MATCH) (2010). County health rankings. Robert Wood Johnson Foundation and University of Wisconsin. Retrieved June 16, 2010 from: http://www.countyhealthrankings.org/oregon.

[35] United States Census Bureau, 2008.

[36] Office for Oregon Health Policy and Research (2010). Oregon health information: Statistics for Lane County. Retrieved July 12, 2010 from: http://www.oregonhealthinfo.com/oregon_health_by_region_display_data.php?OHPRGeo=lane.

[37] Oregon Department of Human Services (2007). Keeping Oregonians healthy: Preventing chronic disease by reducing tobacco use, improving diet, and promoting physical activity and preventive

screenings. Retrieved July 12, 2010 from: http://www.oregon.gov/DHS/ph/hpcdp/docs/healthor.pdf.

[38] Lane Metropolitan Planning Organization (Lane MPO) (2007). Regional Transportation Plan. Retrieved June 16, 2010 from: http://www.thempo.org/prog_proj/rtp.cfm.

[39] Ibid.

[40] National Transit Database. (n.d.). Lane Transit District. Retrieved February 26, 2010 from: http://www.ntdprogram.gov/ntdprogram/cs?action=showRegionAgencies&region=0.

[41] Lane Transit District (2009). Connecting the Community. Retrieved June 16, 2010 from: http://www.ltd.org/pdf/aboutus/LTD%2520Brochure%2520July%25202009%2520web.pdf.

[42] Lane MPO, 2007.

[43] United States Census Bureau (2000). United States Census 2000. Retrieved February 28, 2010 from: http://www.census.gov/main/www/cen2000.html.

[44] Lane MPO, 2007.

[45] Lane Regional Air Protection Agency (2009). 2009 Annual Report. Retrieved July 23, 2010 from: http://www.lrapa.org/downloads/annual_reports/2009_Annual_Report.pdf

[46] Adapted from Centers for Disease Control and Prevention, 2010.

[47] Ewing, R. and Kreutzer, R. (2006). Understanding the Relationship Between the Built Environment and Public Health. A Report Prepared for the LEED-ND Core Committee. Retrieved July 27, 2010 from: http://www.usgbc.org/ShowFile.aspx?DocumentID=1736.

[48] Besser, L.M. and Dannenburg, A.L. (2005). Walking to public transit: steps to help meet physical activity recommendations. *American Journal of Preventive Medicine*, 29(4), 273-280.

[49] Ogilvie, D., Egan, M., Hamilton, V., and Petticrew, M. (2004). Promoting walking and cycling as an alternative to using cars: Systematic review. *British Medical Journal*, 329, 763.

[50] Samaras, C. and Meisterling, K. (2008). Life cycle assessment of greenhouse gas emissions from plug-in hybrid vehicles: Implications for policy. *Environmental Science and Technology*, 42, 3170-3176.

[51] Zhu, L., Cheung, C.S., Zhang, W.G., and Huang, A. (2010). Emissions characteristics of a diesel engine operating on biodiesel and biodiesel blended with ethanol and methanol. *Science of the Total Environment*, 408, 914-921.

[52] Schlossberg, M., Agrawal, A.W., Irvin, K., Bekkouche, V.L. (2007). How Far, by Which Route, and Why? A Spatial Analysis of Pedestrian Preference. Mineta Transportation Institute, College of

Business San José State University. Retrieved June 16, 2010 from: http://transweb.sjsu.edu/mtiportal/research/publications/documents/06-06/MTI-06-06.pdf.

[53] Saelens, B.E. and Handy, S.L. (2008). Built environment correlates of walking: A review. *Medicine and Science in Sports and Exercise*, 40(7S), S550-S566.

[54] McCormack, G., Giles-Corti, B., Lange, A., Smith, T., Martin, K., and Pikora, T.J. (2004). An update of recent evidence of the relationship between objective and self-report measures of the physical environment and physical activity behaviours. *Journal of Science and Medicine in Sports*, 7(1S), 81-92.

[55] Humpel, N., Owen, N., and Leslie, E. (2002). Environmental factors associated with adults' participation in physical activity. *American Journal of Preventive Medicine*, 22(3), 188-199.

[56] Owen, N., Humpel, N., Leslie, E., Bauman, A., and Sallis, J.F. (2004). Understanding environmental influences on walking: Review and research agenda. *American Journal of Preventive Medicine*, 27(1), 67-76.

[57] Heath, G.W., Brownson, R.C., Kruger, J., Miles, R., Powell, K.E., Ramset, L.T., and the Task Force on Community Preventive Services (2006). The effectiveness of urban design and land use and transport policies and practices to increase physical activity: A systematic review. *Journal of Physical Activity and Health*, 3(S1), S55-S76.

[58] Lee, C. and Moudon, A.V. (2004). Physical activity and environment research in the health field: Implications for urban and transportation planning practice and research. *Journal of Planning Literature*, 19(2), 147-181.

[59] McCormack et al., 2004.

[60] Handy, S.L., Boarnet, M.G., Ewing, R., and Killingsworth, R.E. (2002). How the built environment affects physical activity: Views from urban planning. *American Journal of Preventive Medicine*, 23(2S), 64-73.

[61] Owen, Humpel, Leslie, Bauman, & Sallis, 2004.

[62] Lee & Moudon, 2004.

[63] This research used data from the RAND Center for Population Health and Health Disparities, which is funded by grant 1-P50-ES012383 from the National Institute of Environmental Health Sciences. For further information on the CPHHD, go to http://www.rand.org/health/centers/pophealth/index.html.

[64] Wheeler, S.M. (2008). The evolution of landscapes in metropolitan regions. *Journal of Planning Education and Research*, 27, 400-416.

[65] Li, F., Harmer, P.A., Cardinal, B.J., Bosworth, M., Acock, A., Johnson-Shelton, D., and Moore, J.M. (2008). Built environment, adiposity, and physical activity in adults aged 50-75 years. *American Journal of Preventive Medicine*, 35(1), 38-46.

[66] Kitamura, R., Mokhtarian, P.L., and Laidet, L. (1997). A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area. *Transportation*, 24(2), 125-158.

[67] Hoehner, C.M., Brennan Ramirez, L.K., Elliot, M.B., Handy, S.L., and Brownson, R.C. (2005). Perceived and objective environmental measures and physical activity among urban adults. *American Journal of Preventive Medicine*, 28(2S2), 105-116.

[68] McCormack, G.R., Giles-Corti, B., and Bulsara, M. (2008). The relationship between destination proximity, destination mix and physical activity behaviors. *Preventive Medicine*, 46(1), 33-40.

[69] Edwards, R.D. (2008). Public transit, obesity, and medical costs: Assessing the magnitudes. *Preventive Medicine*, 46, 14-21.

[70] Besser & Dannenberg, 2005.

[71] Villanueva, K., Giles-Corti, B., and McCormack, G. (2008). Achieving 10,000 steps: A comparison of public transport users and drivers in a university setting. *Preventive Medicine*, 47, 338-341.

[72] Wener, R.E. and Evans, G.W. (2007). A morning stroll: Levels of physical activity in car and mass transit commuting. *Environment and Behavior*, 39(1), 62-74.

[73] Moudon, A.V., Lee, C., Cheadle, A.D., Garvin, C., Johnson, D.B., Schmid, T.L., and Weathers, R.D. (2007). Attributes of environments supporting walking. *American Journal of Health Promotion*, 21(5), 448-459.

[74] Oregon Department of Human Services (2007). Oregon Overweight, Obesity, Physical Activity, and Nutrition Facts. Retrieved July 19, 2010 from: http://www.oregon.gov/DHS/ph/pan/docs/Oregon_PANfacts_06.pdf.

[75] Blair et al., 1989.

[76] Gregg, Gerzoff, Caspersen, Williamson, & Narayan, 2003.

[77] Hu et al., 2004.

[78] Myers et al., 2004.

[79] Gregg, Gerzoff, Caspersen, Williamson, & Narayan, 2003.

[80] Hu et al., 2004.

[81] Lee, 2003.

[82] Manson, J.E., Nathan, D.M., Krolewski, A.S., Stampfer, M.J., Willett, W.C., and Hennekens, C.H. (1992). A prospective study of exercise and incidence of diabetes among US male physicians. *Journal of the American Medical Association*, 268(1), 63-67.

[83] Oguma & Shinoda-Tagawa, 2004.

[84] Davison, K.K. and Lawson, C.T. (2006). Do attributes in the physical environment influence children's physical activity? A review of the literature. *International Journal of Behavioral Nutrition and Physical Activity*, 3(19).

[85] Yen, I.H., Michael, Y.L., and Perdue, L. (2009). Neighborhood environment in studies of health in older adults: A systematic review. *American Journal of Preventive Medicine*, 37(5), 455-463.

[86] Li et al., 2008.

[87] Lucy, W.H. (2003). Mortality risk associated with leaving home: Recognizing the relevance of the built environment. *American Journal of Public Health*, 93(9), 1564-1569.

[88] Ewing, R., Schieber, R.A., and Zegeer, C.V. (2003). Urban sprawl as a risk factor in motor vehicle occupant and pedestrian fatalities. *American Journal of Public Health*, 93(9), 1541-1545.

[89] Ewing, Schieber, & Zegeer, 2003.

[90] Lovegrove, G.R. and Sayed, T. (2006). Macro-level collision prediction models for evaluating neighbourhood traffic safety. *Canadian Journal of Civil Engineering*, 33, 609-621.

[91] Schefer, D. and Rietvald, P. (1997). Congestion and safety on highways: Towards an analytical model. *Urban Studies*, 34(4), 679-692.

[92] Leden, L. (2002). Pedestrian risk decrease with pedestrian flow. A case study based on data from signalized intersections in Hamilton, Ohio. *Accident Analysis and Prevention*, 34, 457-464.

[93] Wier, M., Weintraub, J., Humphreys, E.H., Seto, E., and Bhatia, R. (2009). An area-level model of vehicle-pedestrian injury collisions with implications for land use and transportation planning. *Accident Analysis and Prevention*, 41, 137-145.

[94] Roberts, I., Norton, R., Jackson, R., Dunn, R., and Hassall, I. (1995). Effect of environmental factors on risk of injury of child pedestrians by motor vehicles: A case-control study. *British Medical Journal*, 310, 91-94.

[95] Leden, 2002.

[96] Jacobsen, P.L. (2003). Safety in numbers: More walkers and bicyclists, safer walking and bicycling. *Injury Prevention*, 9, 205-209.

[97] Jacobsen, 2003.

[98] Robinson, D.L. (2005). Safety in numbers in Australia: More walkers and bicyclists, safer walking and bicycling. *Health Promotion Journal of Australia*, 16, 47-51.

[99] Lovegrove & Sayed, 2006.

[100] Wier, Weintraub, Humphreys, & Seto, 2009.

[101] City of Portland Office of Transportation (2009). Portland Bicycle Count Report 2009. Retrieved July 26, 2010 from:
http://www.portlandonline.com/transportation/index.cfm?c=44671&a=280429.

[102] Transportation Alternatives (2009). Safety in numbers. Retrieved July 26, 2010 from:
http://www.transalt.org/files/newsroom/streetbeat/2009/June/0604.html#safety_in_numbers.

[103] Oregon Department of Transportation (2004-2008). Oregon Traffic Crash Summary. Summary for 2004, 2005, 2006, 2007, and 2008, retrieved July 26, 2010 from:
http://www.oregon.gov/ODOT/TD/TDATA/car/CAR_Publications.shtml.

[104] Frank, L.D., Sallis, J.F., Conway, T.L., Chapman, J.E., Saelens, B.E., and Bachman, W. (2006). Many pathways from land use to health: Associations between neighborhood walkability and active transportation, body mass index, and air quality. *Journal of the American Planning Association*, 72(1), 75-87.

[105] Ibid.

[106] Ewing, R. and Cervero, R. (2001). Travel and the built environment: A synthesis. *Transportation Research Record: Journal of the Transportation Research Board*, 1780, 87-114.

[107] Frank, L.D., Stone, B., and Bachman, W. (2000). Linking land use with household vehicle emissions in the central Puget Sound: Methodological framework and findings. *Transportation Research Part D*, 5, 173-196.

[108] Pope et al., 2002.

[109] Filleul et al., 2005.

[110] Ibid.

[111] Pope et al., 2002.

[112] Pope, C.A., Ezzati, M., and Dockery, D.W. (2009). Fine particulate air pollution and life expectancy in the United States. *New England Journal of Medicine*, 360(4), 376-386.

[113] Schindler, C., Keidel, D., Gerbase, M.W., Zemp, E., Bettschart, R., Brandli, O., Brutsche, M.H., Burdet, L., Karrer, W., Knopfli, B., Pons, M., Rapp, R., Bayer-Oglesby, L., Kunzli, N., Schwartz, J., Liu, L.J.S., Ackermann-Liebrich, U., Rochat, T., and the SAPALDIA Team (2009). Improvements in PM10

exposure and reduced rates of respiratory symptoms in a cohort of Swiss adults (SAPALDIA). *American Journal of Respiratory and Critical Care Medicine*, 179(7), 579-587.

[114] Task Force on Community Preventive Services (2010). Environmental and policy approaches to increase physical activity: Street-scale urban design land use policies & practices. Retrieved July 26, 2010 from: http://www.thecommunityguide.org/pa/environmental-policy/streetscale.html.

[115] Ibid.

[116] Reid, C.E., O'Neill, M.S., Gronlund, C.J., Brines, S.J., Brown, D.G., Diez-Roux, A.V., and Schwartz, J. (2009). Mapping community determinants of heat vulnerability. *Environmental Health Perspectives*, 117(11), 1730-1736.

[117] Lipman, B.J. (2006). A heavy load: The Combined Housing and Transportation Burdens of Working Families. Center for Housing Policy. Retrieved May 14, 2010 from: http://www.nhc.org/pdf/pub_heavy_load_10_06.pdf.

[118] Probst, J.C., Laditka, S.B., Wang, J.Y., and Johnson, A.O. (2007). Effects of residence and race on burden of travel for care: cross sectional analysis of the 2001 US National Household Travel Survey. *BMC Health Services Research*, 7, 40.

[119] Oregon Department of Administrative Services, Office of Economic Analysis (2009). Demographic forecast: Long-term county forecast. Retrieved May 14, 2010 from: http://www.oregon.gov/DAS/OEA/demographic.shtml.

[120] Bailey, L. (2004). Aging Americans: Stranded without Options. Retrieved May 14, 2010 from: http://www.transact.org/library/reports_html/seniors/aging.pdf.

[121] Jacobsen, 2003.

[122] Pucher, J. and Dijkstra, L. (2003). Promoting safe walking and cycling to improve public health: Lessons from the Netherlands and Germany. *American Journal of Public Health*, 93(9), 1509-1516.

[123] Lane MPO, 2007.

[124] Saelens, B.E., Sallis, J.F., and Frank, L.D. (2003). Environmental correlates of walking and cycling: Findings from the transportation, urban design, and planning literatures. *Annals of Behavioral Medicine*, 25(2), 80-91.

[125] Saelens & Handy, 2008.

[126] McCormack et al., 2004.

[127] Owen, Humpel, Leslie, Bauman, & Sallis, 2004.

[128] Humpel, Owen, & Leslie, 2002.

[129] Heath et al., 2006.

[130] Frank, L.D. and Engelke, P. (2000). How land use and transportation systems impact public health: A literature review of the relationship between physical activity and built form. Active Community Environments Initiative Working Paper #1. Retrieved July 26, 2010 from: http://www.cdc.gov/nccdphp/dnpa/pdf/aces-workingpaper1.pdf.

[131] Pucher & Dijkstra, 2003.

[132] American Community Survey 2006-2008.

[133] Davison & Lawson, 2006.

[134] Leden, 2002.

[135] Jacobsen, 2003.

[136] Ibid.

[137] Robinson, 2005.

[138] Jacobsen, 2003.

[139] Robinson, 2005.

[140] Leden, 2002.

[141] City of Portland Office of Transportation, 2009.

[142] Transportation Alternatives, 2009.

[143] Frank, L.D. and Engelke, P. (2005). Multiple impacts of the built environment on health: Walkable places and the exposure to air pollution. *International Regional Science Review*, 28(2), 193-216.

[144] Rank, J., Folke, J., and Jespersen, P.H. (2001). Differences in cyclists and car drivers exposure to air pollution from traffic in the city of Copenhagen. *The Science of the Total Environment*, 279(1-3), 131-136.

[145] van Wijnen, J.H., Verhoeff, A.P., Jans, H.W.A., van Brugge, M. (1995). The exposure of cyclists, car drivers and pedestrians to traffic-related air pollutants. *International Archives of Occupational and Environmental Health*, 67(3), 187-193.

[146] de Hartog, J.J., Boogaard, H., Nijland, H., and Hoek, G. (2010). Do the health benefits of cycling outweigh the risks? *Environmental Health Perspectives* doi:10.1289/ehp.0901747. Retrieved July 26, 2010 from: http://ehp03.niehs.nih.gov/article/info:doi/10.1289/ehp.0901747.

[147] Haire, A., Figliozzi, M., Monsere, C., George, L., Moore, A., and Kendrick, C. (2010). Measuring the links between traffic flows and emissions in urban areas. *Northwest Transportation Conference*, Portland, OR. Retrieved July 26, 2010 from: http://egov.oregon.gov/ODOT/TD/TP_RES/docs/2010NWTC/2010_presentations/Ashley_Haire.pdf.

[148] National Complete Streets Coalition (2005-2009). Complete streets FAQ. Retrieved May 14, 2010 from: http://www.completestreets.org/complete-streets-fundamentals/complete-streets-faq/.

[149] Dellinger, A.M. (2002). Barriers to children walking and biking to school – United States, 1999. *MMWR*; 51(32), 701-704. Retrieved April 12, 2010 from: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5132a1.htm.

[150] Cooper, A.R., Anderson, L.B., Wedderkopp, N., Page, A.S., and Froberg, K. 2005. Physical activity levels of children who walk, cycle, or are driven to school. *American Journal of Preventive Medicine*, 29(3), 179-184.

[151] Timperio, A., Crawford, D., Telford, A., and Salmon, J. (2004). Perceptions about the local neighborhood and walking and cycling among children. *Preventive Medicine*, 38(1), 39-47.

[152] National Highway Traffic Safety Administration (2007). Traffic Safety Facts: Pedestrians. Publication DOT HS 810 994. Retrieved April 13, 2010 from: http://www.dmv.ne.gov/highwaysafety/pdf/TSFPedestrian2007.pdf.

[153] Xiang, H., Zhu, M., Sinclair, S.A., Stallones, L., Wilkins III, J.R., Smith, G.A. (2006). Risk of vehicle–pedestrian and vehicle–bicyclist collisions among children with disabilities. *Accident Analysis and Prevention,* 38(6), 1064-1070.

[154] National Highway Traffic Safety Administration (1997). Wheelchair Users Injuries and Deaths Associated with Motor Vehicle Related Incidents. Retrieved July 26, 2010 from: http://www.nhtsa.gov/people/ncsa/wheelchr.html.

[155] Koepsell, T., McCloskey, L., Wolf, M., Moudon, A.V., Buchner, D., Kraus, J., and Patterson, M. (2002). Crosswalk markings and the risk of pedestrian-motor vehicle collisions in older pedestrians. *Journal of the American Medical Association*, 288, 2136-2143.

[156] Langlois, J.A., Keyl, P.M., Guralnik, J.M., Foley, D.J., Marottoli, R.A., and Wallace, R.B. (1997). Characteristics of older pedestrians who have difficulty crossing the street. *American Journal of Public Health*, 87, 393-397.

[157] Michael, Y.L., Green, M.K., and Farquhar, S.A. (2006). Neighborhood design and active aging. *Health and Place*, 12(4), 734-740.

[158] Spivock, M., Gauvin, L., Riva, M., and Brodeur, J-M. (2008). Promoting active living among people with physical disabilities: Evidence for neighborhood-level buoys. *American Journal of Preventive Medicine*, 34(4), 291-298.

[159] Kirchner, C., Gerber, E., and Smith, B. (2008). Designed to deter: Community barriers to physical activity for people with visual or motor impairments. *American Journal of Preventive Medicine*, 34(4), 349-352.

[160] National Transit Database, n.d.

[161] LaChapelle, U. and Frank, L.D. (2009). Transit and health: Modes of transport, employer-sponsored public transit pass programs, and physical activity. *Journal of Public Health Policy*, 30, S73-S94.

[162] Edwards, 2008.

[163] Besser & Dannenburg, 2005.

[164] Villanueva, Giles-Corti, & McCormack, 2008.

[165] Wener & Evans, 2007.

[166] Moudon et al., 2007.

[167] MacDonald, J.M., Stokes, R.J., Cohen, D.A., Kofner, A., and Ridgeway, G.K. (2010). The effect of light rail transit on body mass index and physical activity. *American Journal of Preventive Medicine*, 39(2), 105-112.

[168] Timperio, Crawford, Telford, & Salmon, 2004.

[169] de Bourdeaudhuij, I., Sallis, J.F., and Saelens, B.E. (2003). Environmental correlates of physical activity in a sample of Belgian adults. *American Journal of Health Promotion* 18(1), 83-92.

[170] Evenson, K.R., Birnbaum, A.S., Bedimo-Rung, A.L., Sallis, J.F., Voorhees, C.C., Ring, K., and Elder, J.P. (2006). Girls' perception of physical environmental factors and transportation: Reliability and association with physical activity and active transport to school. *International Journal of Behavioral Nutrition and Physical Activity*, 3(28).

[171] Hoehner, Ramirez, Elliot, Handy, & Brownson, 2005.

[172] Taylor, L.M., Leslie, E., Plotnikoff, R.C., Owen, N., and Spence, J.C. (2008). Associations of perceived community environmental attributes with walking in a population-based sample of adults with Type 2 Diabetes. *Annals of Behavioral Medicine,* 35(2), 170-178.

[173] Lane Council of Governments (LCOG) (2002). TransPlan. Retrieved June 16, 2010 from: http://www.lcog.org/transplan.cfm.

[174] American Public Transit Association (2009). 2009 Public Transportation Fact Book, 60th Edition. Retrieved July 26, 2010 from: http://www.apta.com/gap/policyresearch/Documents/APTA_2009_Fact_Book.pdf.

[175] Strathman, J.G., Wachana, P., and Callas, S. (2010). Analysis of bus collision and non-collision incidents using transit ITS and other archived operations data. *Journal of Safety Research*, 41, 137-144.

[176] Ibid.

[177] Ibid.

[178] TenBrink, D.S., McMunn, R., and Panken S. (2009). Project U-Turn: Increasing active transportation in Jackson, Michigan. *American Journal of Preventive Medicine*, 37(6S2), S329-S335.

[179] Huberty, J.L., Dodge, T., Peterson, K., and Balluff, M. (2009). Activate Omaha: The journey to an active living environment. *American Journal of Preventive Medicine*, 37 (6S2), S428-S435.

[180] Luton, J. (n.d.). PBIC Case Study – Victoria, British Columbia. Bike to work week: A case study in successful behavior change. Retrieved April 23, 2010 from: http://drusilla.hsrc.unc.edu/cms/downloads/ENC.BiketoWorkWeek.pdf.

[181] Mutrie, N., Carney, C., Blamey, A., Crawford, F., Aitchison, T., and Whitelaw, A. (2002). "Walk in to Work Out": A randomised controlled trial of a self help intervention to promote active commuting. *Journal of Epidemiology and Community Health*, 56, 407-412.

[182] Oregon Department of Transportation (2007). Individual Transportation Options Pilot Project: Final report of Indimark and Behavioral Analysis. Retrieved April 11, 2010 from: http://www.oregon.gov/ODOT/PT/PROGRAMS/TRANS_OPTIONS/TRAVEL_SMART/TravelSmartMar07Rpt.pdf.

[183] Ogilvie, Egan, Hamilton, & Petticrew, 2004.

[184] ICF Consulting (2005). Assessing the Effects of Freight Movement on Air Quality at the National and Regional Level. Prepared for the U.S. Federal Highway Administration. Retrieved April 2, 2010 from: http://www.oregon.gov/ODOT/TD/FREIGHT/docs/publications/federal/FHWAFrtAirQualRep1.pdf.

[185] Oregon Environmental Public Health Tracking (2008). Air Quality (1999-2007): Nationally consistent data and measures. Retrieved April 3, 2010 from: http://www.oregon.gov/DHS/ph/epht/docs/airrep.pdf.

[186] Lane Regional Air Protection Agency (2009). 2009 Annual Report. Retrieved July 23, 2010 from: http://www.lrapa.org/downloads/annual_reports/2009_Annual_Report.pdf.

[187] Bell, M.L. and Dominici, F. (2008). Effect modification by community characteristics on the short-term effects of ozone exposure and mortality in 98 US communities. *American Journal of Epidemiology*, 167(8), 986-997.

[188] United States Environmental Protection Agency (2008). Particulate matter: Health and environment. Retrieved May 9, 2010 from: http://www.epa.gov/air/particlepollution/health.html.

[189] Pope, Ezzati, & Dockery, 2009.

[190] United States Environmental Protection Agency (2008a). Ground-level ozone: Health and environment. Retrieved May 9, 2010 from: http://www.epa.gov/air/ozonepollution/health.html.

[191] Trasande, L.T., and Thurston, G.D. (2005). The role of air pollution in asthma and other pediatric morbidities. *The Journal of Allergy and Clinical Immunology*, 115(4), 689-699.

[192] Ritz, B., Yu, F., Chapa, G., and Fruin, S. (2000). Effects of air pollution on preterm birth among children born in Southern California between 1989 and 1993. *Epidemiology*, 11(5), 502-511.

[193] Trasande & Thurston, 2005.

[194] Eugene Water and Electric Board (n.d.). Electric resources portfolio. Retrieved July 26, 2010 from: http://www.eweb.org/resources/portfolio.

[195] Portland General Electric (2009). How we generate energy. Retrieved July 26, 2010 from: http://www.portlandgeneral.com/our_company/corporate_info/how_we_generate_energy.aspx.

[196] Samaras & Meisterling, 2008.

[197] Stephan, C.H. and Sullivan, J. (2008). Environmental and energy implications of plug-in hybrid-electric vehicles. *Environmental Science and Technology*, 42, 1185-1190.

[198] Electric Power Research Institute (2007). Environmental Assessment of Plug-in Hybrid Electric Vehicles. Volume 2: United States air quality analysis based on AEO-2006 assumptions for 2030. Retrieved May 14, 2010 from: http://mydocs.epri.com/docs/public/000000000001015326.pdf.

[199] United States Environmental Protection Agency (2007a). Particulate matter. Retrieved May 9, 2010 from: http://www.epa.gov/oms/invntory/overview/pollutants/pm.htm.

[200] United States Environmental Protection Agency (2007b). Nitrogen oxides. Retrieved May 9, 2010 from: http://www.epa.gov/oms/invntory/overview/pollutants/nox.htm.

[201] Oregon Department of Environmental Quality (n.d). Reducing air pollution with biodiesel. Retrieved May 7, 2010 from: http://www.deq.state.or.us/aq/diesel/reducepollution.htm.

[202] United States Environmental Protection Agency (2002). A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions. Retrieved May 7, 2010 from: http://www.epa.gov/oms/models/analysis/biodsl/p02001.pdf.

[203] McCormick, R.L. (2007). The impact of biodiesel on pollutant emissions and public health. *Inhalation Technology*, 19, 1033-1039.

[204] Ibid.

[205] Chen, Y-C. and Wu, C-H. (2002). Emissions of submicron particles from a direct injection diesel engine by using biodiesel. *Journal of Environmental Science and Health*, A37(5), 829-843.

[206] United States Environmental Protection Agency (2008).

[207] Pope et al., 2002.

[208] Filleul et al., 2005.

[209] Pope et al., 2002.

[210] Pope, Ezzati, & Dockery, 2009.

[211] Schindler et al., 2009.

[212] US EPA, 2002.

[213] Zhai, H., Frey, H.C., Rouphail, N.M., Concalves, G.A., and Farias, T.L. (2009). Comparison of flexible fuel vehicle and life-cycle fuel consumption and emissions of selected pollutants and greenhouse gases for ethanol 85 versus gasoline. *Journal of Air and Waste Management*, 59, 912-924.

[214] Lin, W.Y., Chang, Y.Y., Hsieh, Y.R. (2010). Effect of ethanol-gasoline blends on small engine generator energy efficiency and exhaust emission. *Journal of Air and Waste Management*, 60, 142-148.

[215] Jacobsen, M.Z. (2007). Effects of ethanol (E85) versus gasoline vehicles on cancer and mortality in the United States. *Environmental Science and Technology*, 41, 4150-4157.

[216] Hansen, A.C., Zhang, Q., and Lyne, P.W.L. (2005). Ethanol-diesel fuel blends – a review. Bioresource Technology, 96, 277-285.

[217] Zhu, Cheung, Zhang, & Huang, 2010.

[218] Finkelstein, M.M., Jerrett, M., DeLuca, P., Finkelstein, N., Verma, D.K., Chapman, K., and Sears, M.R. (2003). Relation between income, air pollution and mortality: A cohort study. *Canadian Medical Association Journal*, 169(5), 397-402.

[219] Hill, J., Tilman, D., Polasky, S., and Tiffany, D. (2006). Environmental , economic, and energetic costs and benefits of biodiesel and ethanol biofuels. *Proceedings of the National Academy of Sciences of the United States of America*, 103 (3), 11206-11210.

[220] Ibid.

[221] Jaeger, W.K., Cross, R., Egelkraut, T.M. (2007). Biofuel Potential in Oregon: Background and Evaluation of Options. Special Report 1078. Oregon State University. Retrieved May 9, 2010 from: http://extension.oregonstate.edu/catalog/pdf/sr/sr1078.pdf.

[222] Centers for Disease Control and Prevention (CDC)(2010a). CDC Recommendations for Improving Health through Transportation Policy. Retrieved July 27, 2010 from: http://www.cdc.gov/transportation/docs/FINAL CDC Transportation Recommendations-4-28-2010.pdf.

[223] Woodcock et al., 2009.

[224] Lane MPO, 2007.

[225] City of Copenhagen (2002). Cycle Policy 2002-2012. Retrieved July 30, 2010 from: http://www.vejpark2.kk.dk/publikationer/pdf/413_cykelpolitik_uk.pdf.

[226] Harris, E.C., Lindsay, A., Heller, J.C., Gilhuly, K., Williams, M., Cox, B., and Rice, J. (2009). Humboldt County General Plan Update Health Impact Assessment: A Case Study. *Environmental Justice*, 2(3), 127-134.

[227] San Francisco Department of Public Health, Program on Health Equity and Sustainability (n.d.) Health Development Measurement Tool. Retrieved July 30, 2010 from: http://www.thehdmt.org/.