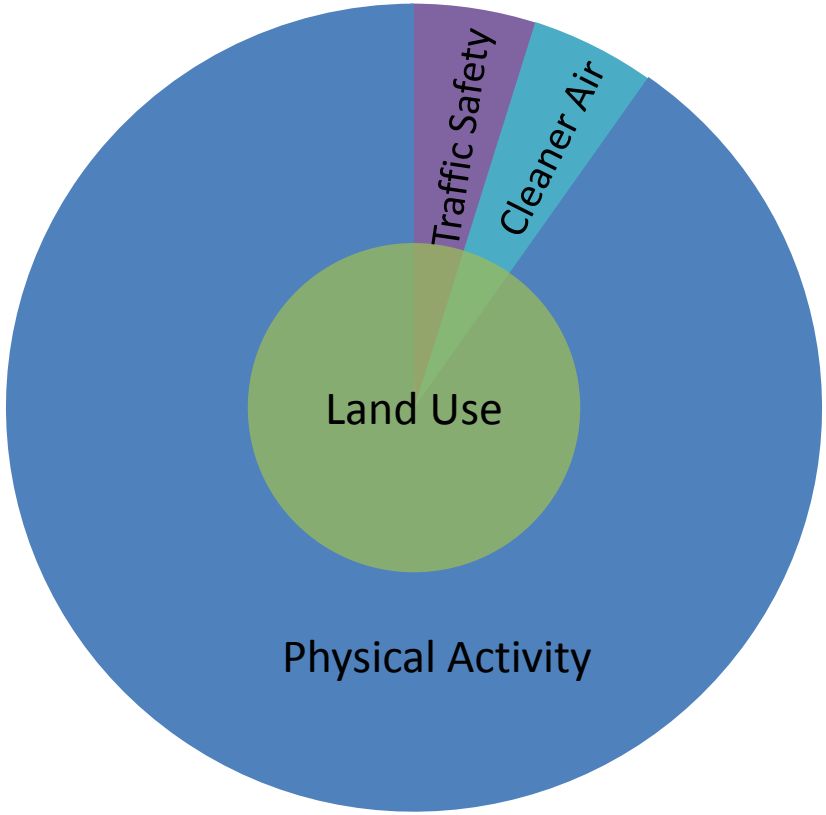
Community Climate Choices Health Impact Assessment



Advisory Group Meeting
November 12, 2013

Oregon Health Authority

Health determinants

Social and Environmental Determinants of Health

HIA: Definition

HIA is a systematic process that uses an array of data sources and analytic methods and considers input from stakeholders to determine the potential effects of a proposed policy, plan, program, or project on the health of a population and the distribution of the effects within the population. HIA provides recommendations on monitoring and managing those effects.

--the National Research Council

Oregon Health Authority

HIA: In Oregon

2008, Portland Health Impact Assessment Workgroup, Columbia River Crossing HIA

2009, two HIAs in Oregon

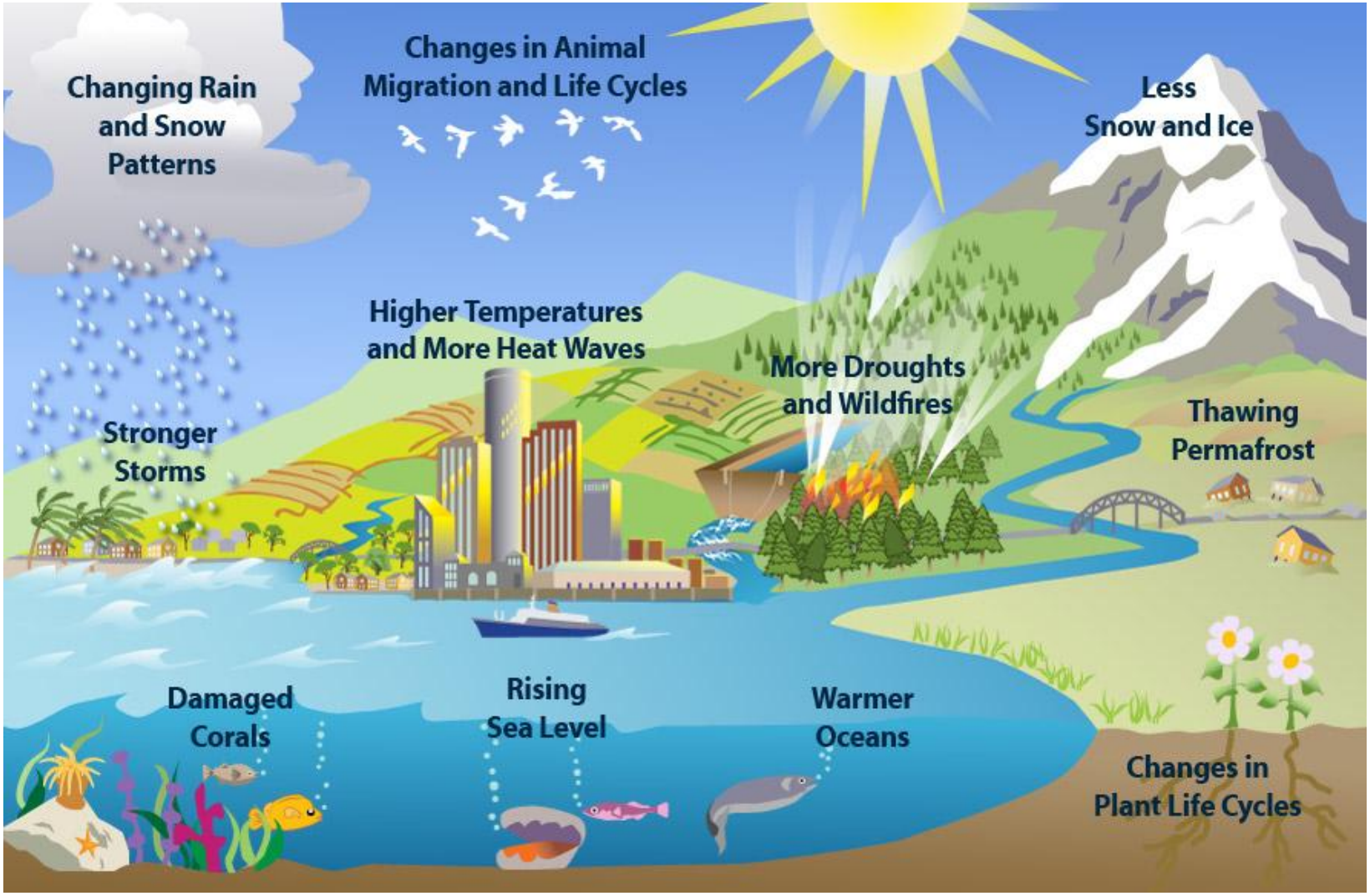
2009-2010, OPHD receives ASTHO funds: 3 OHA/county HIAs, 3 additional Oregon HIAs

2011, OPHD receives CDC funds: State-led Wind Energy HIA, 2 county-led HIAs, 4 additional Oregon HIAs

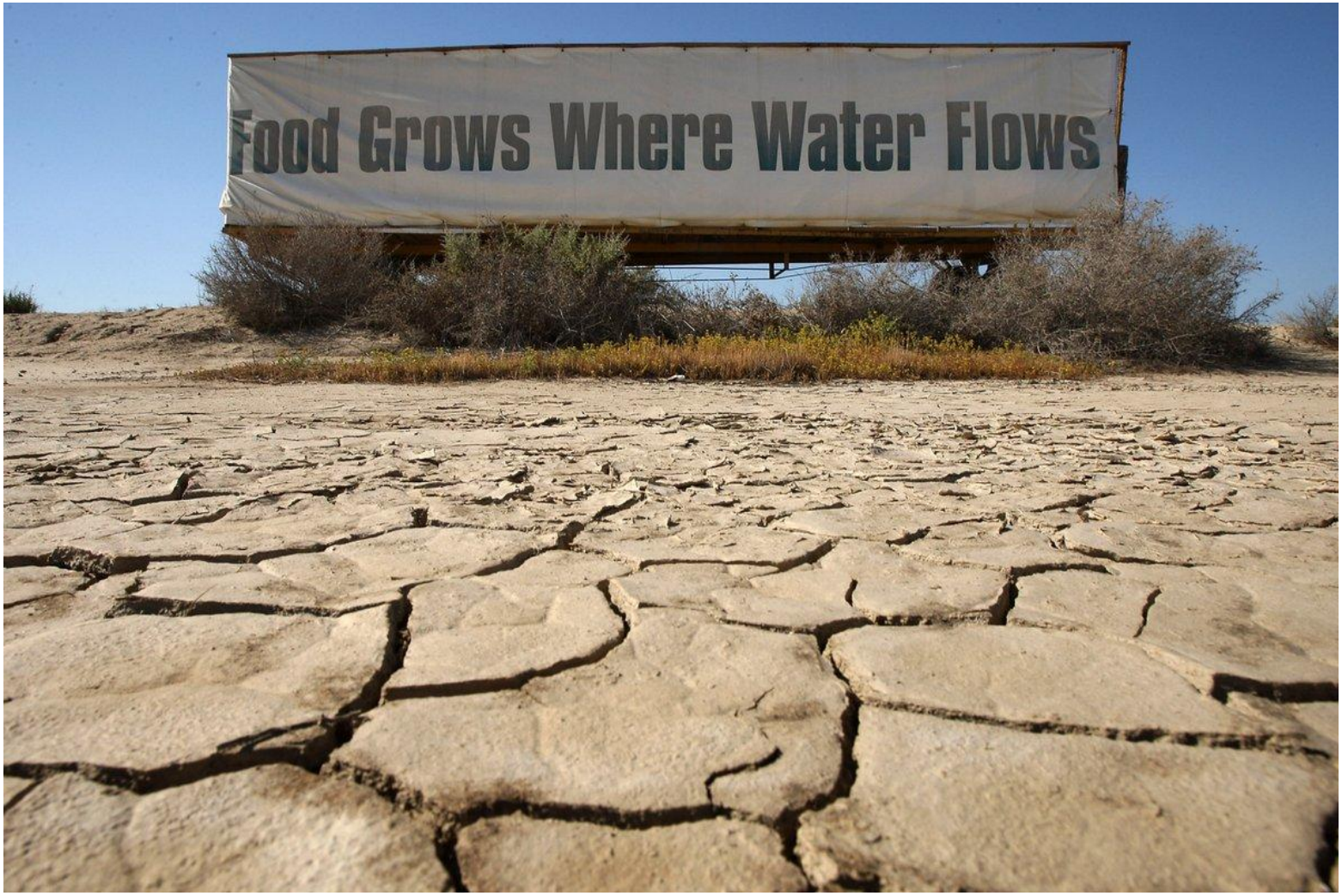
2012: State-led Climate Smart Scenarios HIA, 2 county-led HIAs, 1 additional Oregon HIA

2013, OHA receives Pew funds: State-led Community Climate Choices HIA, Transportation Options HIA, 2 county-led HIAs, 2 additional Oregon HIAs

Oregon Health Authority

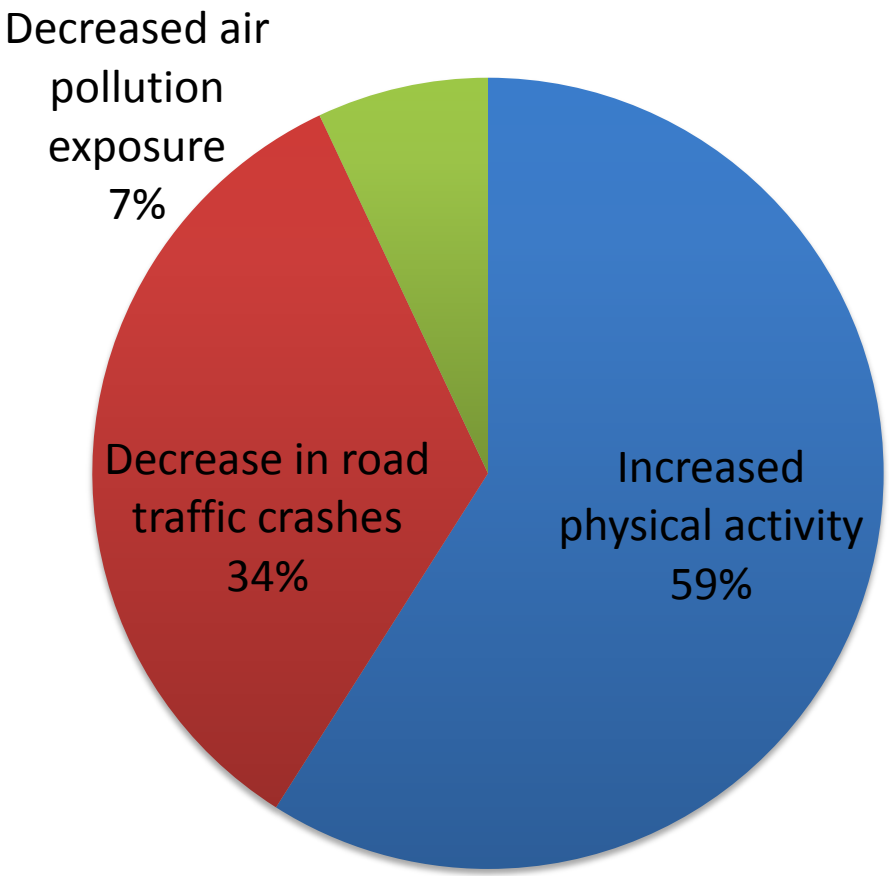


Oregon Health Authority



Oregon Health Authority

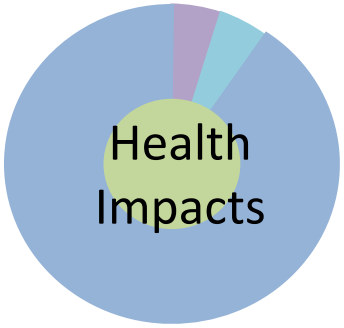
Climate Smart Communities Scenarios HIA: Health impacts



Climate Smart Communities Scenarios HIA: Key recommendations

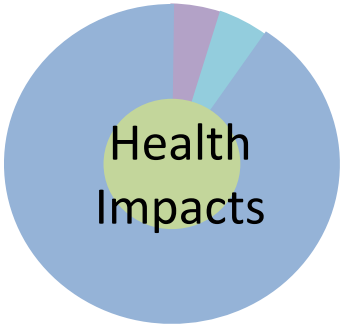
- Develop and implement a preferred scenario that meets or surpasses the greenhouse gas emissions reduction target set for the region.
- Emphasize strategies that best increase active transportation and physical activity: community design, pricing and incentives – to maximize public health benefits and meet the state target.
- Include strategies, such as community design, that can lead to decreases in road traffic injuries and fatalities for all populations in the region, in particular for children

SCOPE



- Rerun ITHIM for Scenarios A, B, and C
  - Pathways considered are physical activity, traffic safety, and long-term exposure to air pollution
- Address land-use levers through updated lit review
- Investigate air pollution beyond PM2.5
- Evaluate including monetization
  - Only as a framing tool to show extent of externality

CHRONIC DISEASE: CONDITIONS OF CONCERN



Chronic conditions are a major health burden

Heart Disease + Stroke

29% of death in Oregon

Prevalence in tri-county area

- 2.2% have had a heart attack
- 2.0% have chest pain
- 2.0% have had a stroke

Respiratory Disease

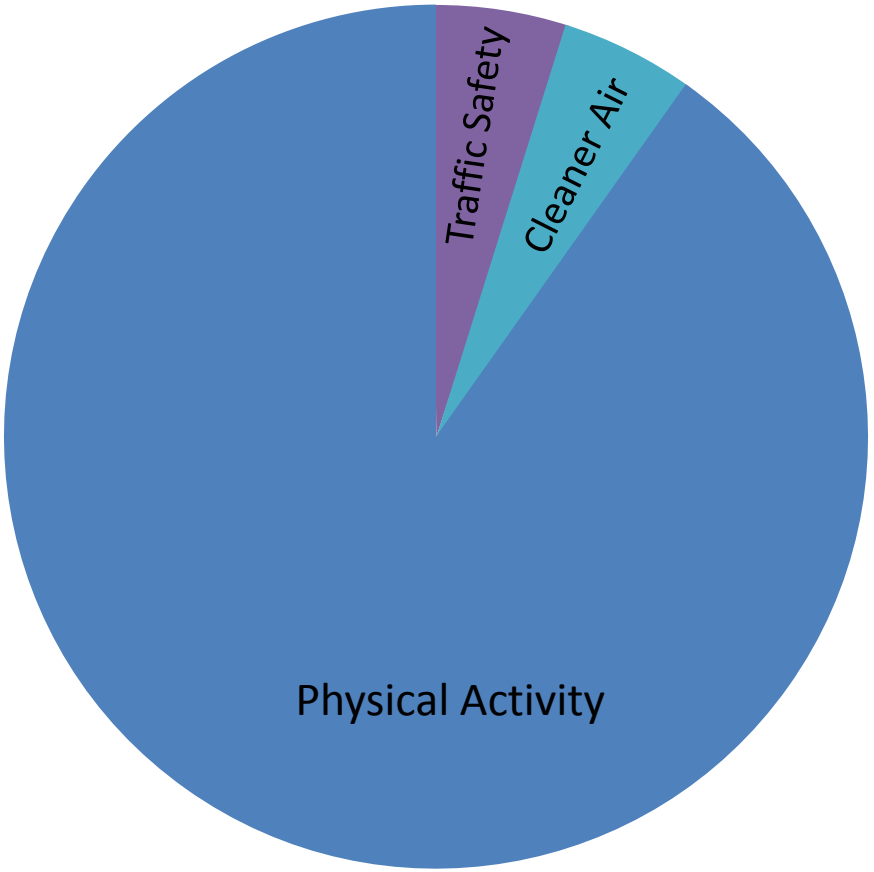
4% of death in Oregon

Prevalence in tri-county area

- 5.7 % COPD in Oregon
- 1041 cases of lung cancer
- 8.6% pediatric asthma rates
- 9.2% adult asthma rates

ITHIM* RESULTS SUMMARY
Avoided Deaths

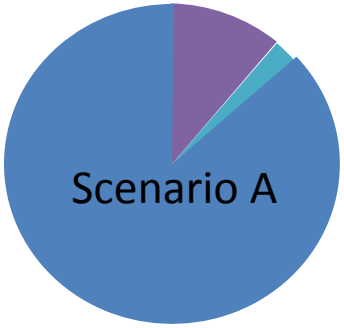
Pathway	Scenario	Avoided Deaths	
		Count	*Percent of Scenario*
Physical Activity	A	-44	*91%*
	B	-67	*91%*
	C	-87	*86%*
Traffic Safety	A	-1	*2%*
	B	-3	*5%*
	C	-10	*10%*
Air Pollution	A	-3	*6%*
	B	-4	*5%*
	C	-4	*4%*

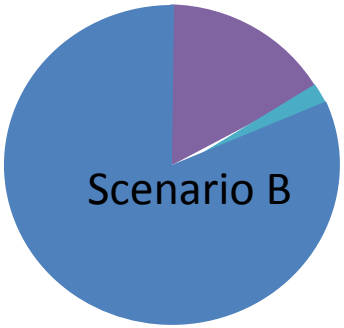


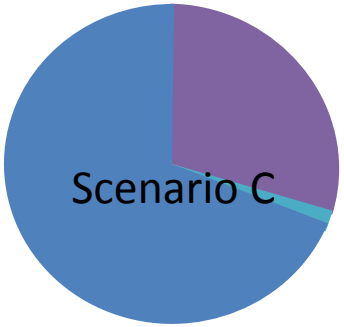
*Developed by James Woodcock. For more information, see http://www.cedar.iph.cam.ac.uk/research/modelling/ithim/

ITHIM RESULTS SUMMARY
Avoided Morbidity (Illness)

Pathway	Scenario	Avoided Morbidity (Illness)			
		YLL	YLD	DALY	
				Count	*Percent of Scenario*
Physical Activity	A	-217	-245	-462	*84%*
	B	-361	-441	-802	*80%*
	C	-520	-601	-1121	*69%*
Traffic Safety	A	0	-33	-72	*13%*
	B	-116	-67	-183	*18%*
	C	-345	-144	-489	*30%*
Air Pollution	A	-19	0	-19	*3%*
	B	-22	0	-22	*2%*
	C	-24	0	-24	*1%*

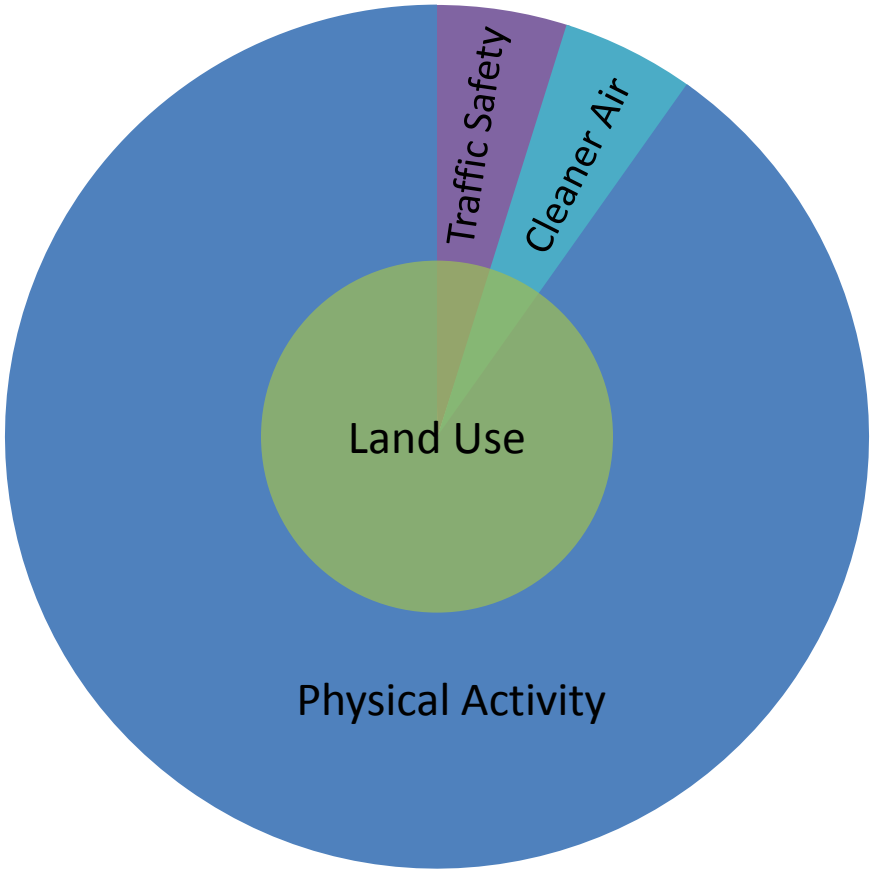


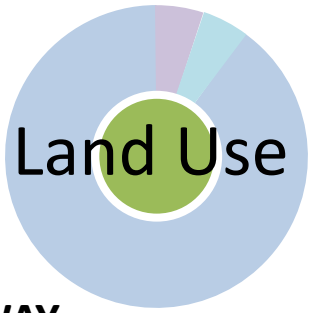




Land Use

- Mediator of other pathways
- Most strategies are necessary but not sufficient pre-conditions for active transportation





Land-Use Lever	Current Levels	Scenario A/B/C	Health Impact (magnitude)	Quality of Evidence
Households in mixed use areas	26%	+10% + 11% +11%	+++	+++++

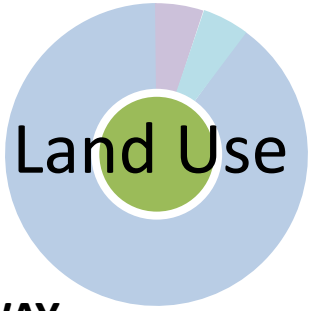
HEALTH PATHWAY

Mixed land uses is a necessary pre-condition to increased active transportation and physical activity.

- Residential density
- Decreased distance to a diversity of destinations

ADDITIONAL CONSIDERATIONS

- Design Matters
- Mixed land-use + housing for mix of incomes
  - Multi-unit apartment buildings are often a land-use buffer, but also need to be fully integrated
- Concentrated air/noise pollution
  - Housing along major arterials is exposed to higher concentrations of air pollutants and noise



Land-Use Lever	Current Levels	Scenario A/B/C	Health Impact (magnitude)	Quality of Evidence
Urban Growth Boundary Expansion (Density/Sprawl)	2010 UGB	+28,000 acres +12,000 acres +12,000 acres	+++	++++

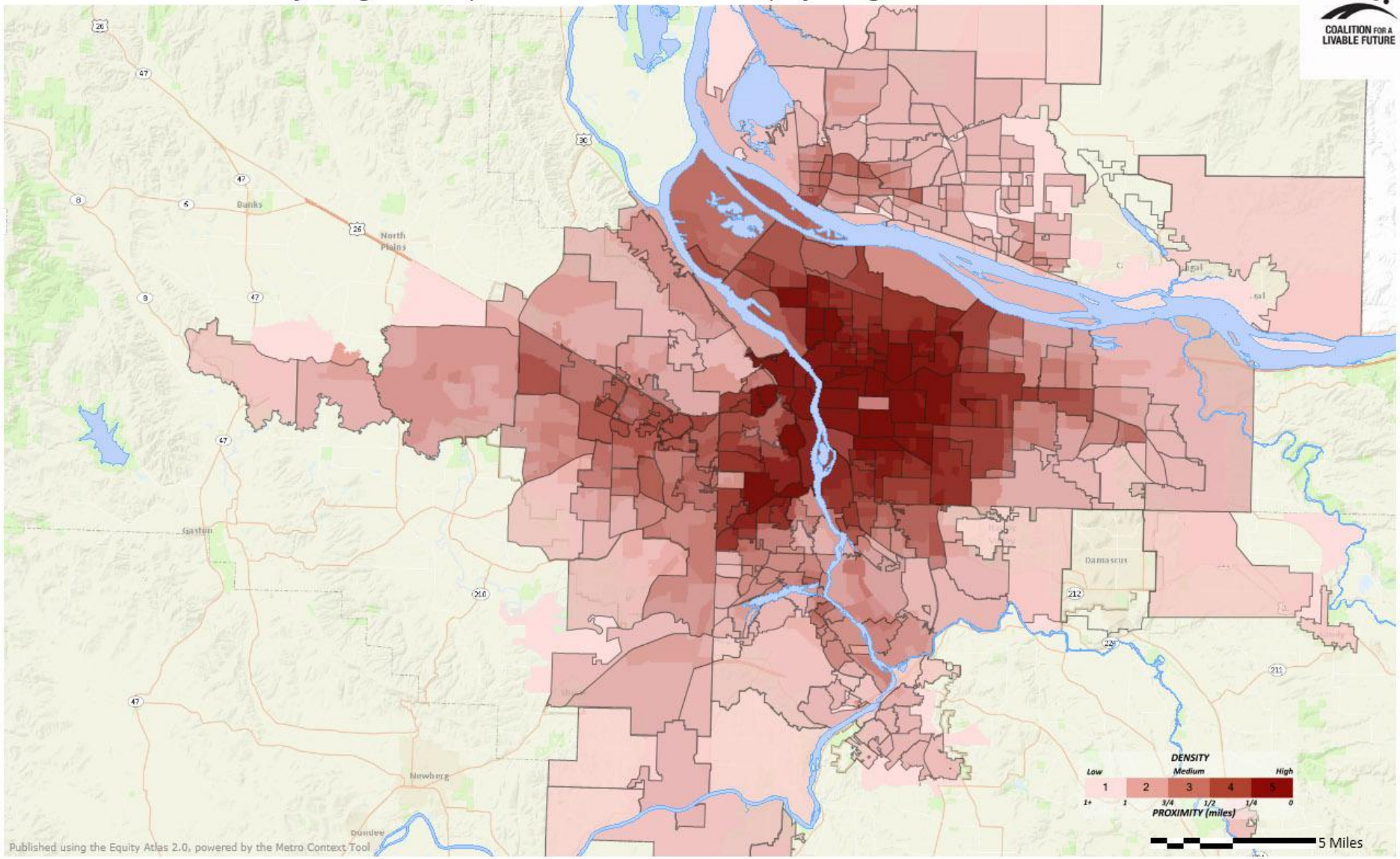
HEALTH PATHWAY

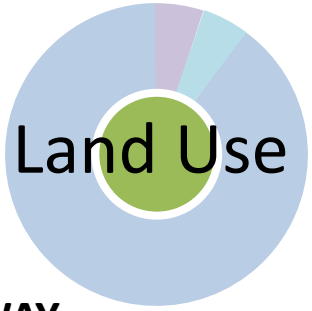
- Density is generally health supportive because nearby available resources increase.
- Residential density in particular leads to increased physical activity as individuals shift to active transportation modes for daily activities.

ADDITIONAL CONSIDERATIONS

- Density without connectivity is problematic
- Density can exacerbate concentrated air and noise pollution
- Density potentially increases commute times.
- UBG may put upward pressure on housing prices
    - potentially exacerbates patterns of locating low-income households in outer areas with limited resources.

Transit Access to Family Wage Jobs (60 Minutes Travel Time) by Neighborhood





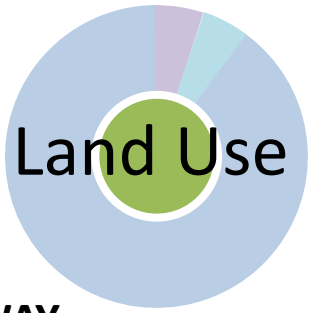
Land-Use Lever	Current Levels	Scenario A/B/C	Health Impact (magnitude)	Quality of Evidence
SOV trips (<10 mi round trip) shifting to bike	9%	+1% +6% +11%	++++	+++ (mode shift) +++++ (health)

HEALTH PATHWAY

Aggressive mode shifts to bicycles will increase physical activity and health.

ADDITIONAL CONSIDERATIONS

- The access, placement, and design of bike facilities must maintain perceived and real safety (see Traffic Safety Section)
- Placement and design should also minimize air pollution exposure when possible.
- Low-income communities access to bike culture also needs to be addressed.



Land-Use Lever	Current Levels	Scenario A/B/C	Health Impact (magnitude)	Quality of Evidence
Transit Service (daily revenue mi)	73,000	+7,000 +14,000 +86,000	+++	+++++ (mode shift) +++ (health)

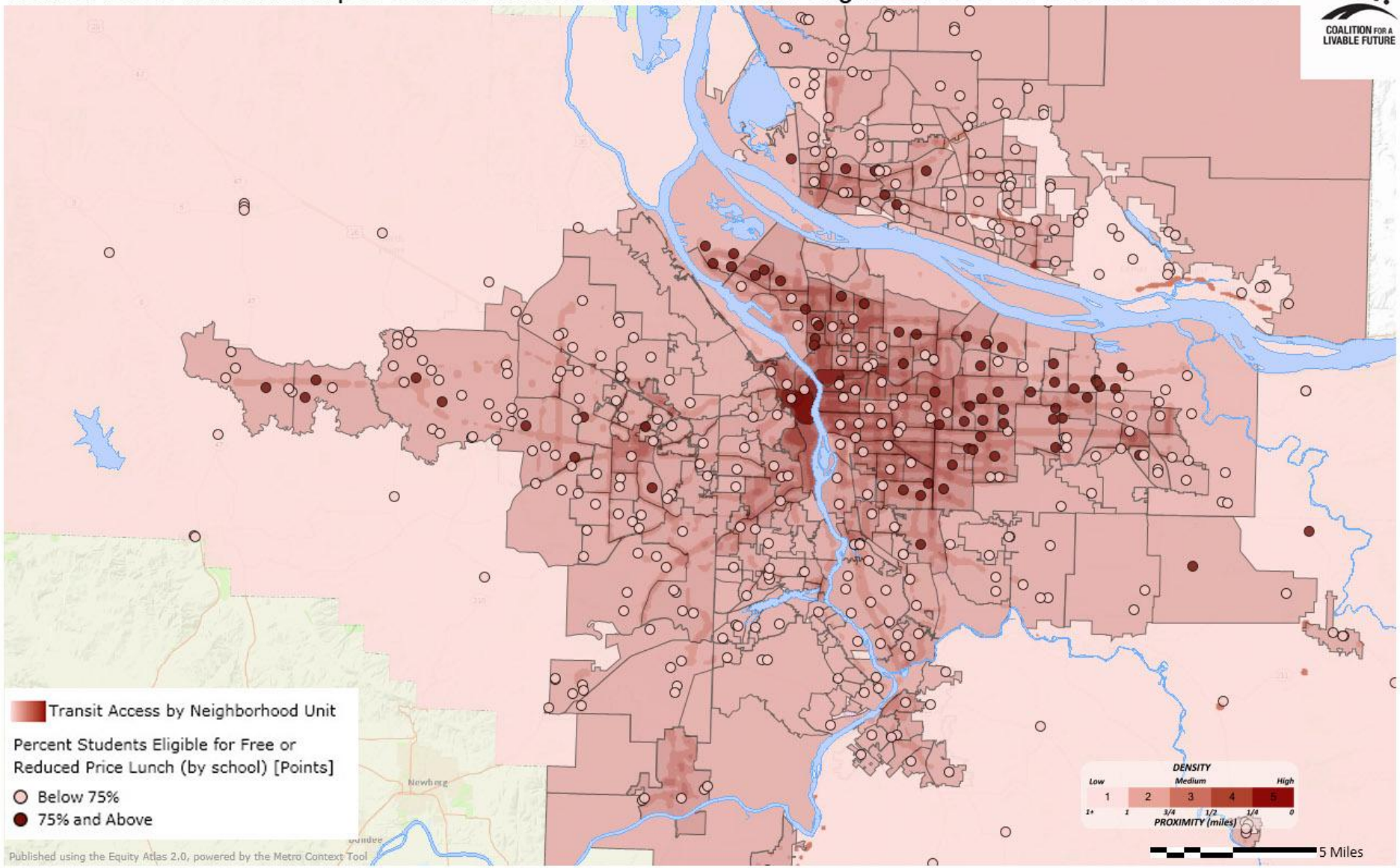
HEALTH PATHWAY

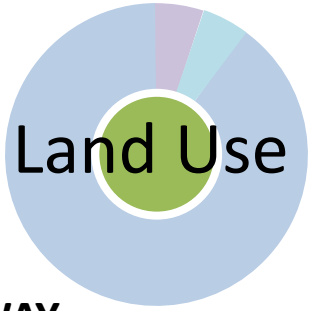
Increased transit service increases physical activity (walking to/from stops), decreases air pollution, and increases traffic safety.

ADDITIONAL CONSIDERATIONS

- Low-income households are more likely to be transit dependent and may, in certain cases, have less access to transit. This group is also highly sensitive to increased transit costs.
- Return on investment suggests increasing transit full-fares areas and to build rail lines in areas where redevelopment potential can be maximize. However, expansions of service should prioritize reaching low-income neighborhoods.

Transit Access in Relationship to Schools with 75% or More Students Eligible for Free or Reduced Price Lunch





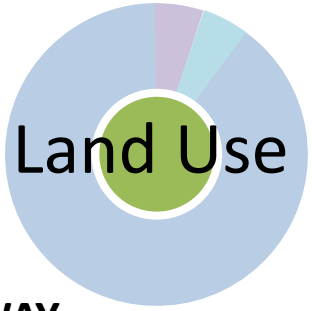
Land-Use Lever	Current Levels	Scenario A/B/C	Health Impact (magnitude)	Quality of Evidence
Work/non-work trips in areas with parking management	13%/8%	No Change +17%/+22% +37%/42%	***	+++++ (mode shift) + (health)

HEALTH PATHWAY

Parking management incentivizes active transportation and physical activity

ADDITIONAL CONSIDERATIONS

For low-income households, the potential burden of parking costs and access to alternative transportation modes should be considered.



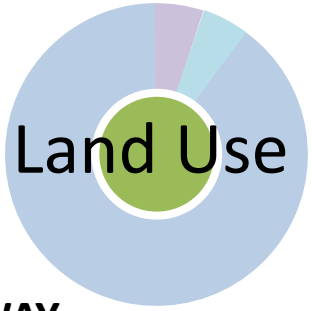
Land-Use Lever	Current Levels	Scenario A/B/C	Health Impact (magnitude)	Quality of Evidence
Miles of Freeway/ Arterials Added	N/A	+9 miles +81 miles +105 miles		++ ++++

HEALTH PATHWAY

- Adding roads to decrease congestion leads to decreased traffic injuries and fatalities, increased time for healthy activities, and decreased air pollution.
- Major roads are a significant barrier to active transportation, physical activity and social cohesion.

ADDITIONAL CONSIDERATIONS

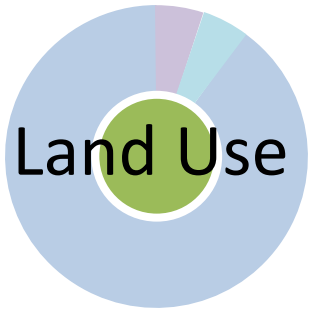
- Induced demand may erode the congestion related pathways over time.
- Health impacts of additional lanes are extremely localized and vary by project; each project should carefully assess the impact on nearby residents and mitigate air quality, noise, and physical barriers when possible.
- Arterials may help complete the grid as the road system is completed and trigger multi-mode improvements; care should be taken in designing multi-mode improvements to maximize health.



Land-Use Lever	Current Levels	Scenario A/B/C	Health Impact (magnitude)	Quality of Evidence
Delay reduced by traffic management strategies	10%	No change +10% +25%	+	+++

HEALTH PATHWAY

Addressing congestion leads to increased time for healthy activities, increased access to health supportive resources, and decreased air pollution and traffic collisions.



Other multi-modal investments

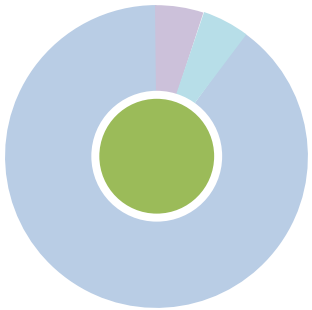
Scenario B

- **New street connections** that further build out the regional street grid and arterial street expansion are constructed throughout system.
- Major streets are widened or retrofitted with **wider sidewalks, safer street crossings, improved bus stops, bikeways, transit signal priority at intersections** and other multi-modal designs.
- **On-street bicycle and pedestrian projects**, such as bicycle lanes, cycle tracks, bicycle boulevards, sidewalks and crossing improvements are constructed.
- **Off-street regional trail projects** are constructed, such as the Lake Oswego to Portland trail, South waterfront Willamette Greenway trail, Fanno Creek (Red Electric) trail, Beaverton Creek Trail, Westside trail, Bronson Creek trail, Council Creek trail, Tonquin trail, Columbia Slough trail, Scouter's Mountain trail, the Sunrise Project trail and Springwater trail, Oregon City Loop trail, a segment of the E. Buttes Loop trail, and the Gresham-Fairview trail.

Scenario C adds

- The **regional Active Transportation Plan recommended regional pedestrian and bicycle networks are completed**, including the spiderweb bicycle network. The spiderweb network encompasses diagonal bicycle parkways radiating from the Portland central city that are connected by circular bicycle parkways that connect nearly all town centers.

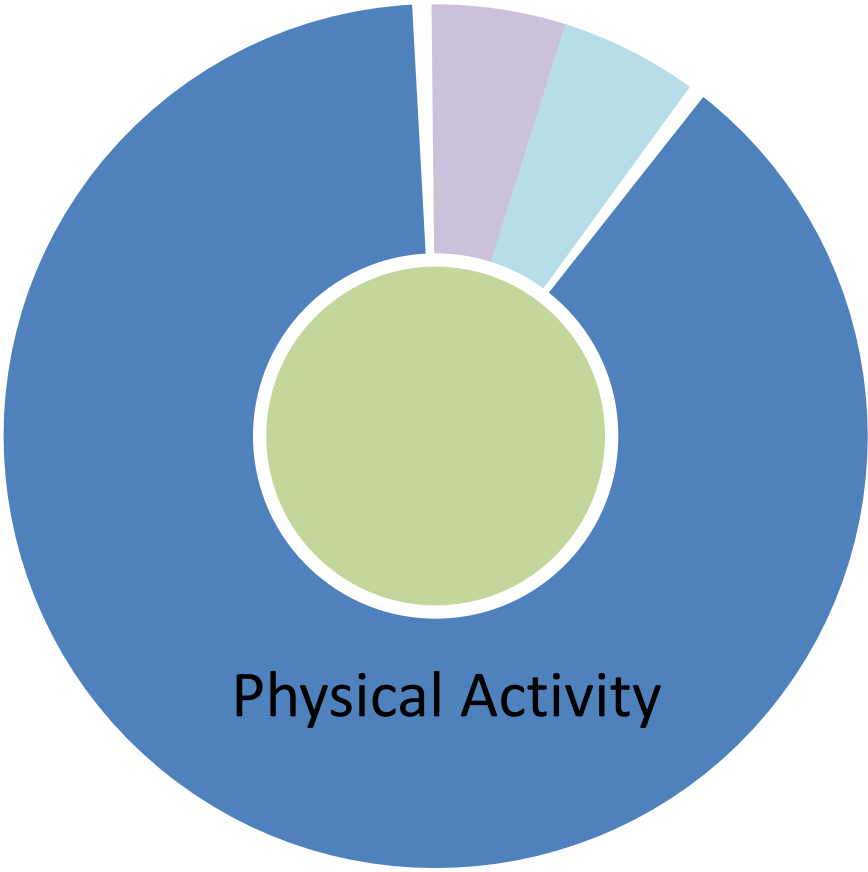
Land Use Summary



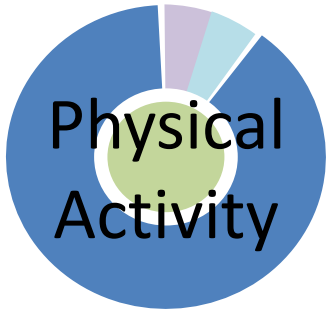
- Land use strategies
  - overlap with the 3 health pathways
  - are necessary but not sufficient pre-conditions for active living
- Health beneficial investments are multi-modal
  - How does this investment help ALL types of users?
  - Freeway and rail expansion may erode funding for other investments
- Continual low-income spatial lens needed

ITHIM Results for Physical Activity

		Scenario		
		A	**B**	**C**
Bike Mode-Split		10%	15%	20%
Avoided	**Deaths**	-44	-67	-87
	Percent of Scenario	*91%*	*91%*	*86%*
	YLL	-217	-361	-520
	YLD	-245	-441	-601
	DALY	-462	-802	-1121
	Percent of Scenario	*84%*	*80%*	*69%*



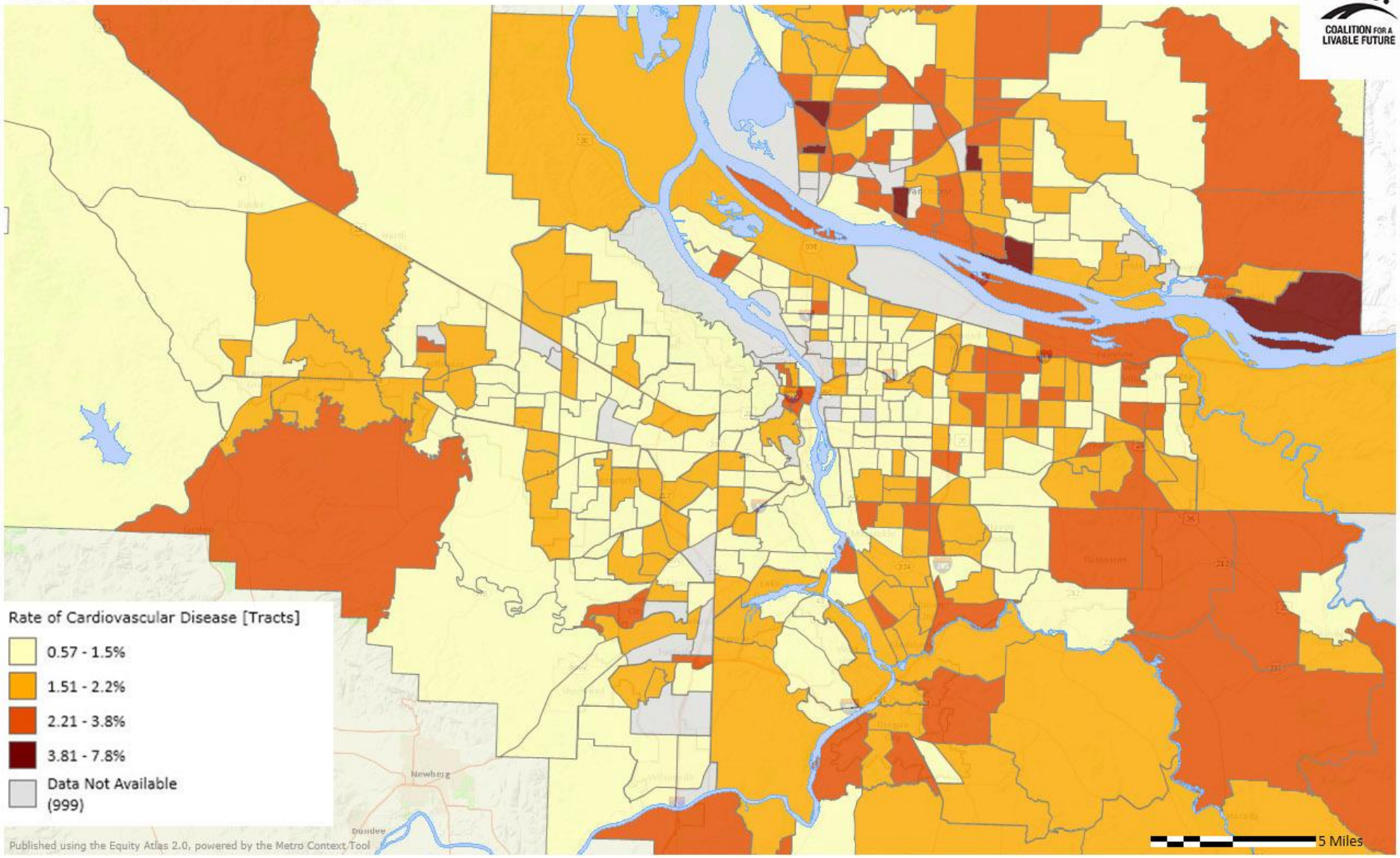
Chronic Disease of Concern



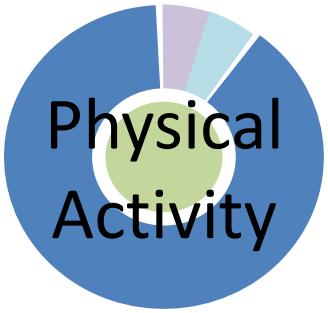
Heart Disease + Stroke

- 29% of death in Oregon
- In tri-county area
  - 2.2% have had a heart attack
  - 2.0% have chest pain
  - 2.0% have had a stroke
- Oregon Health Plan spends annually in the UGB
  - $31.2 mil on heart disease and congestive heart failure
  - $41.7 mil on stroke
  - $58.5 mil on hypertension patients (Note may overlap with above)

Cardiovascular Disease Rates



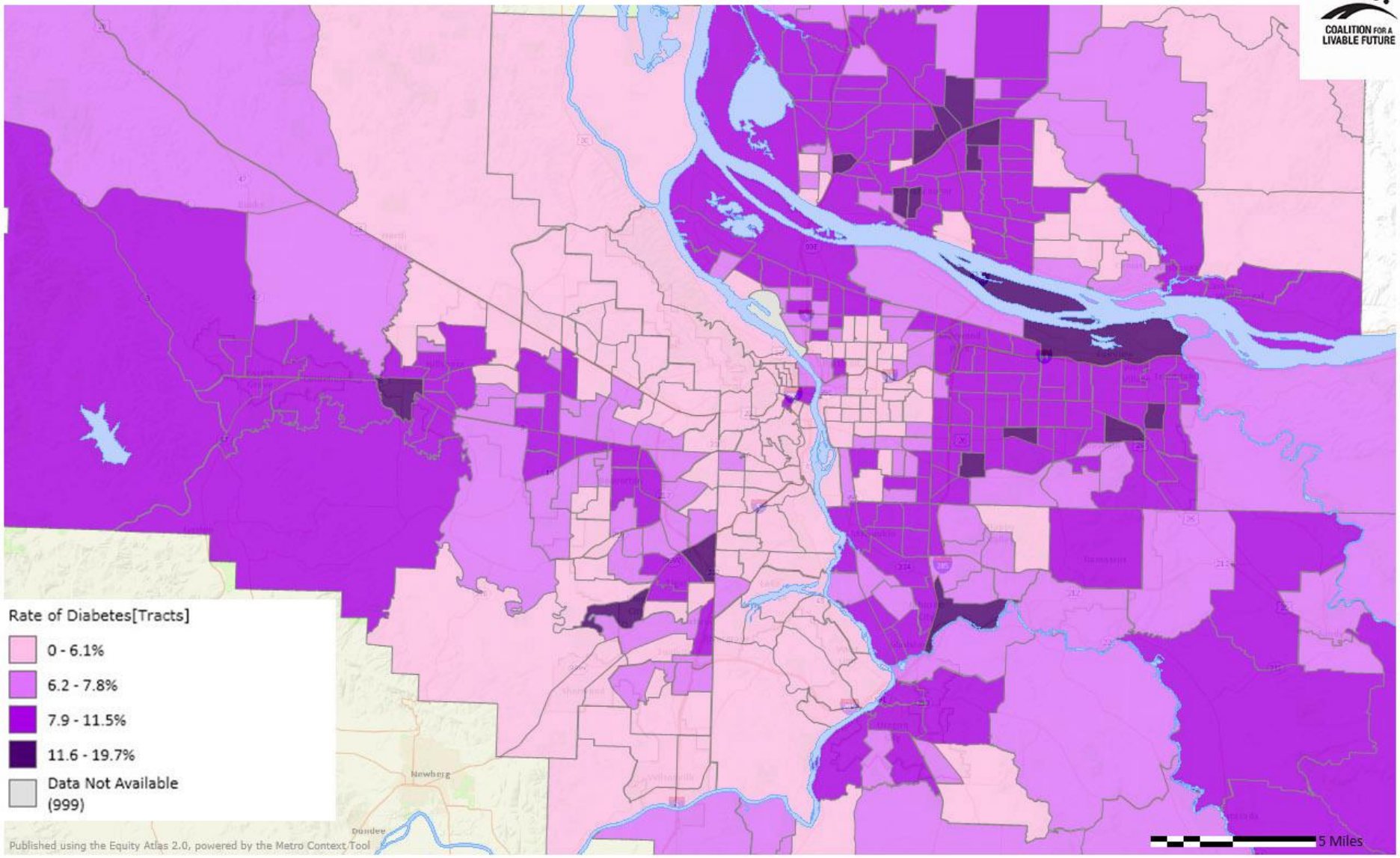
Chronic Disease of Concern

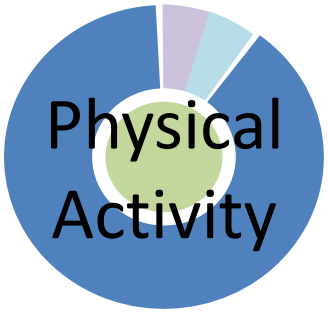


Diabetes

- 8.5% prevalence in MSA (2011)
- Approximately 4% of death burden
- Oregon Health Plan spends **$53.9 mil** annually in the UGB

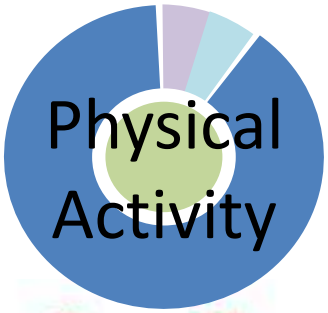
Diabetes Rates



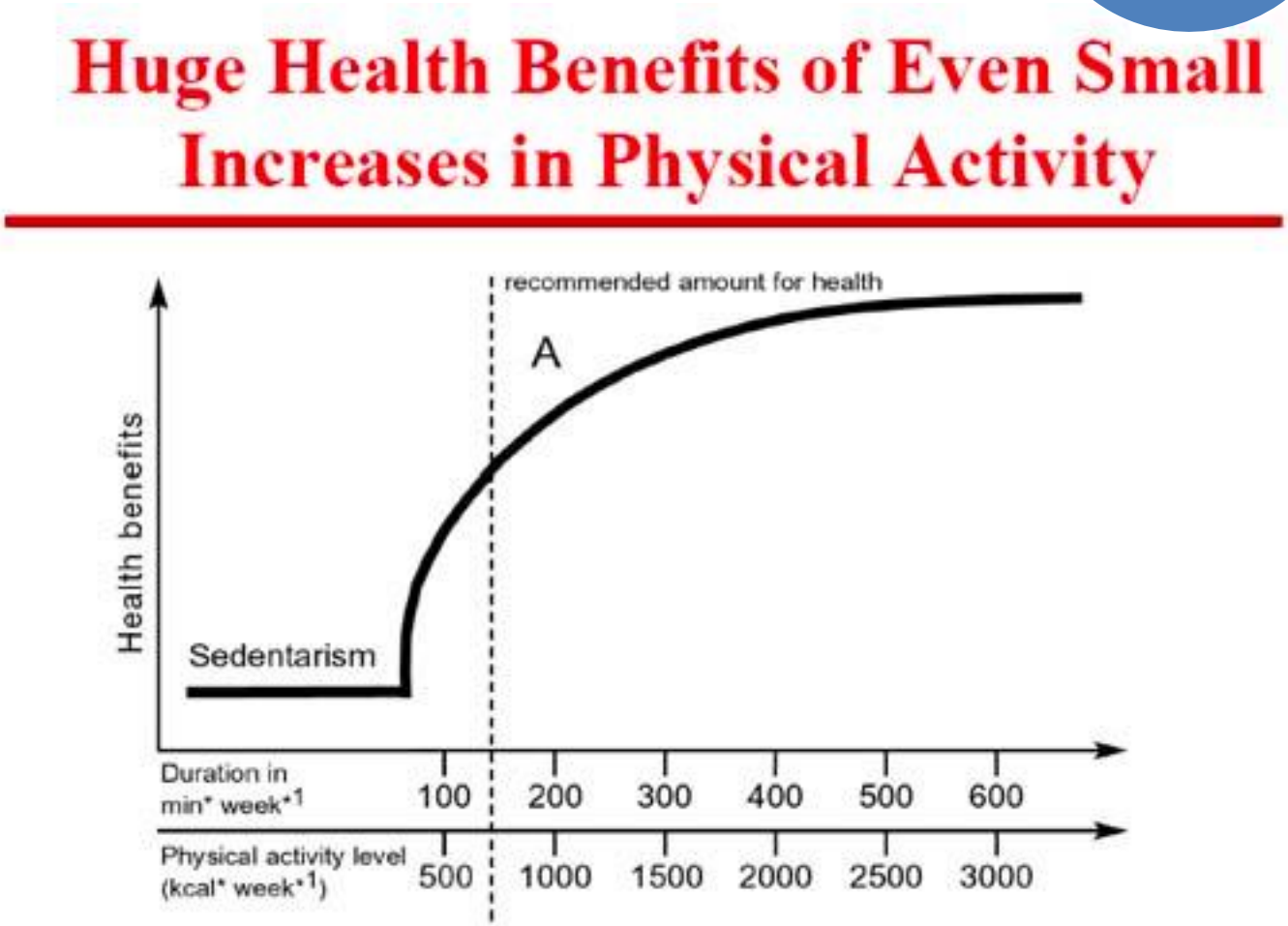


- Physical activity is one of 4 major behavioral changes to address chronic disease
  - Smoking, diet, excessive alcohol
- Preventative
  - ↓BMI
- AND Prescriptive
  - Performs as well or better than drugs for addressing heart disease, stroke, diabetes

PHYSICAL ACTIVITY GOAL

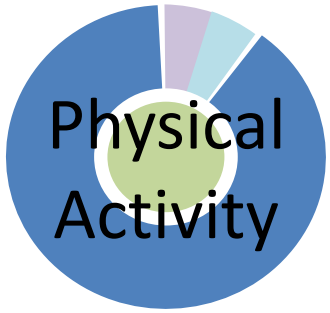


- 150 minutes per week for adults
- 300 minutes per week for kids



Bouchard C. Physical activity and health: introduction to the dose-response symposium. Medicine and Science in Sports and Exercise 2001; 33: S347-350

PHYSICAL ACTIVITY GOAL



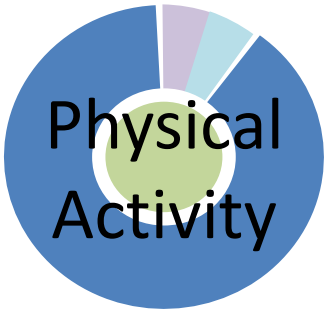
Who meets in Oregon (2009)?

- 56% of adults
- 57.5% of 8th graders, 44.3% of 11th graders

How does transit help? Nationally,

- 29% of those who use transit SOLEY during commute
- Transit users walk 8.3 more minutes a day than auto users

20-30 MINUTE GOAL BY MODE

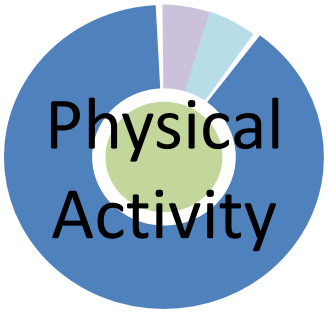


Mode	Commute Time, 1-way (minutes)
SOV	23.8
Carpool	25.8
Public Transit*	44.5
Mean	25.1

* Includes time to walk to stop and wait for transit

Source: U.S. Census (2012). American Community Survey, 1 year estimates for Port-Vanc MSA

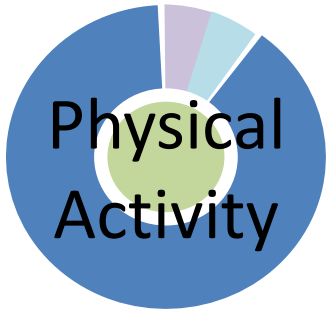
20-30 MINUTE GOAL BY MODE



	Round Trip (miles)	Commute Time (minutes)
Bike	5	25
	10	50
Pedestrian	1/2 : (Pedestrian only trip to store and back)	10
	1: (Bus - 1/4 mile walk at origin and destination)	20
	2: (Rail - 1/2 mile walk at origin and destination)	40

Assumes 12 mi/hr for biking, 3 mi per hour for walking

Land Use Matters

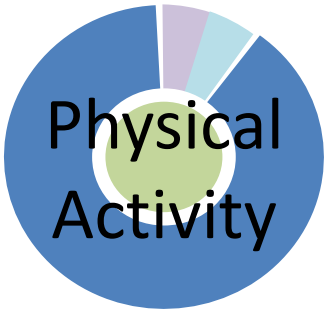


- Transit Service Expansion
- Mixed-use, residential density, and connectivity all increase physical activity

Multi-modal investment in Scenario B

- New street connections
- Wider sidewalks
- Safer street crossings
- Improved bus stops
- Bikeways
- Transit signal priority at intersections
- On street bike and ped projects
- Off street regional trail projects
- Regional ped/bike network completed (Scenario C)

Land Use Matters



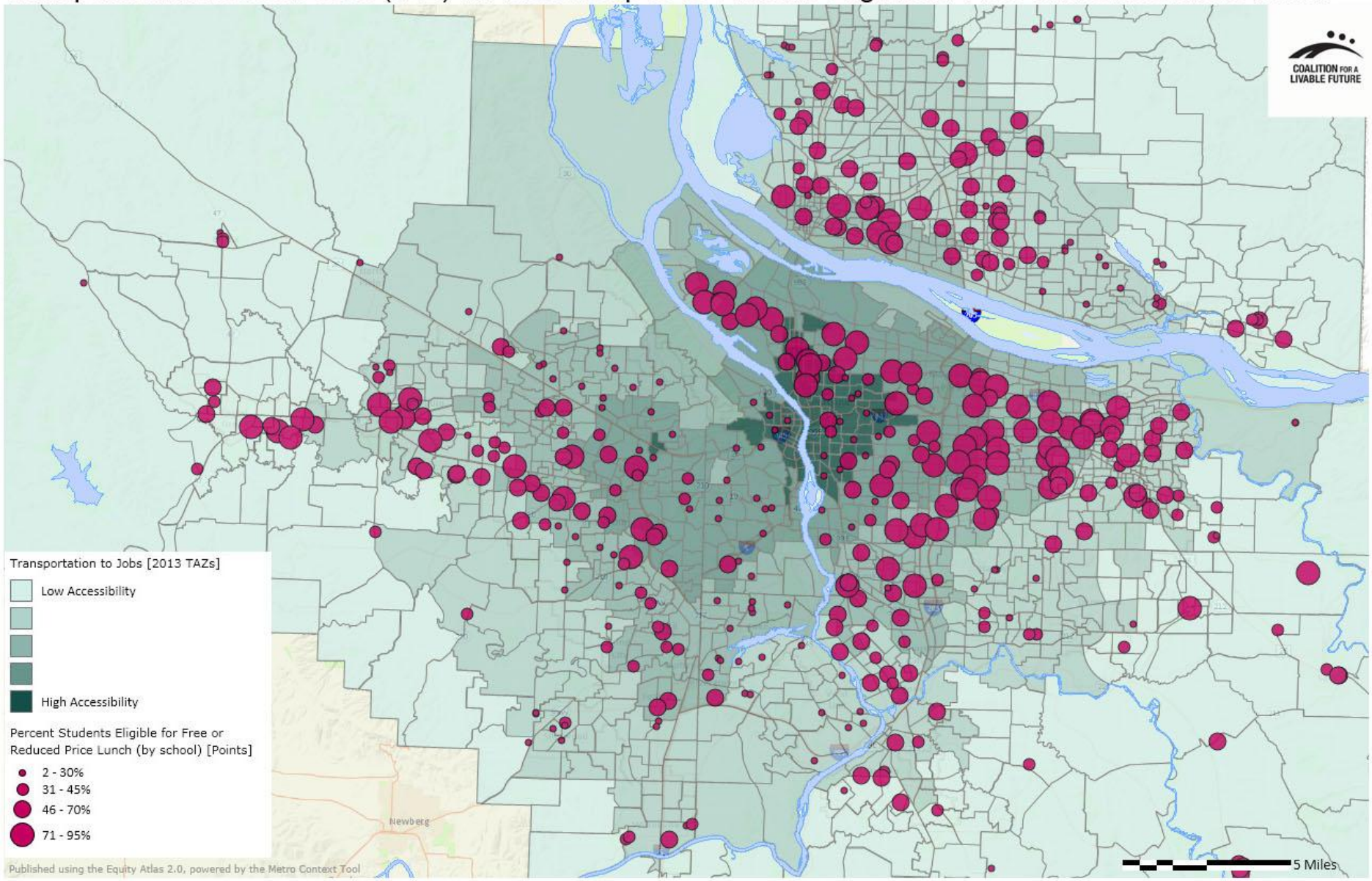
Spatial distribution of low-income households

– Transit dependency (16+ yrs, work commute)

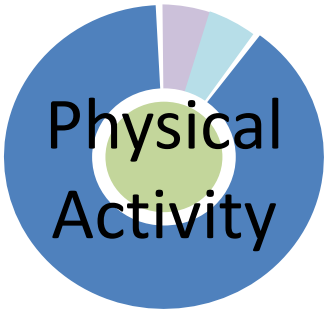
	SOV	Carpool	Public Transit
Median Earnings	$37,874	$28,902	$25,857
Below Poverty	50%	15%	13%
100-150% Poverty	57%	15%	10%
150%+	74%	9%	5%

Source: U.S. Census (2012). American Community Survey, 1 year estimates for Port-Vanc MSA

Transportation Access to Jobs (TAZ) in Relationship to % Students Eligible for Free or Reduced Price Lunch



Land Use Matters

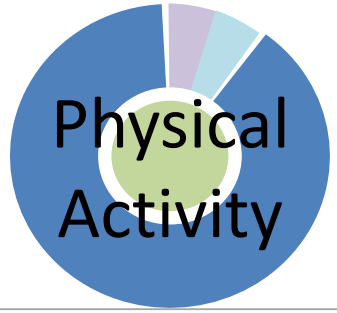


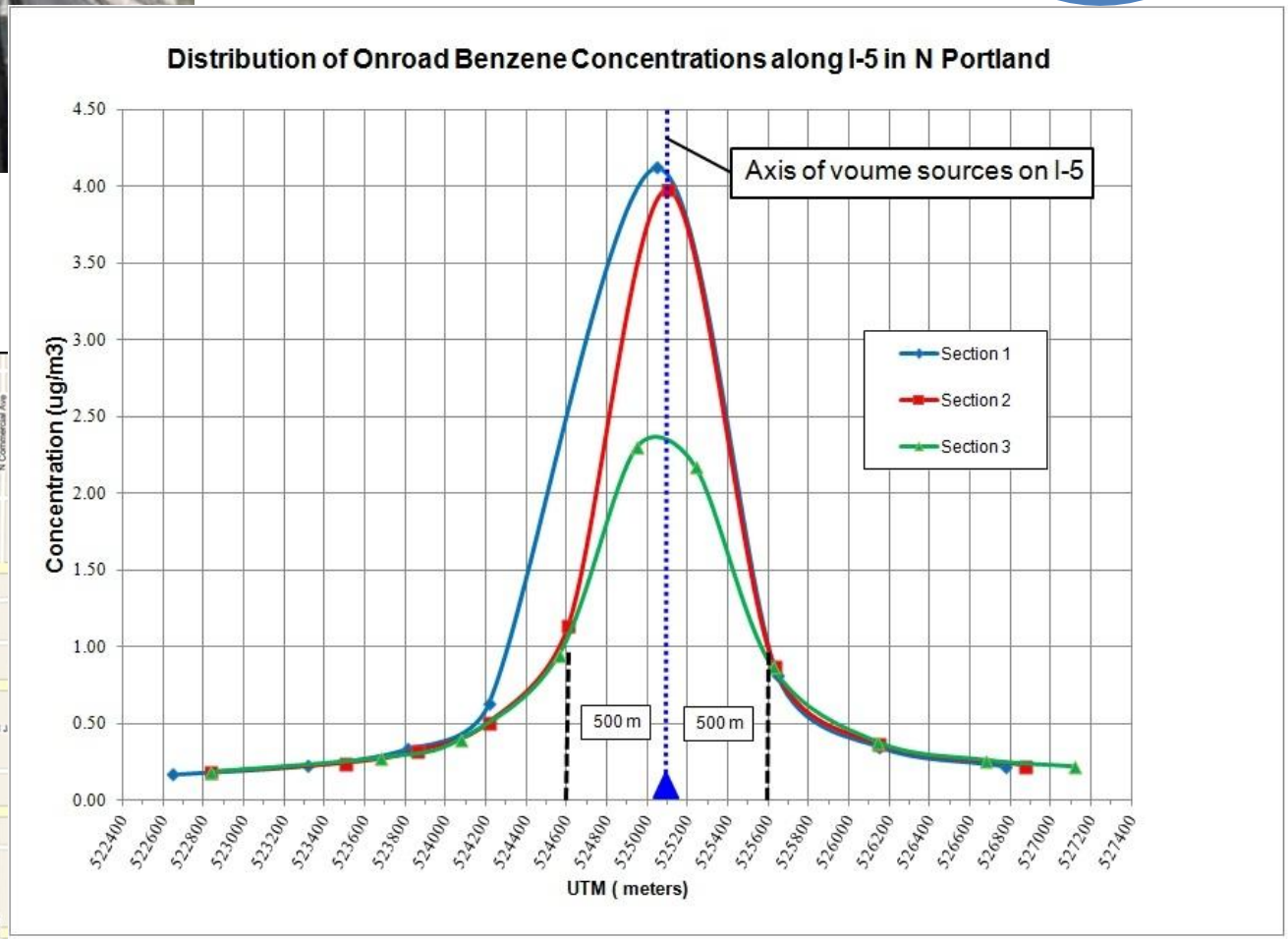
Spatial distribution of low-income households

- Income is a significant determinant of health
- Search for affordable housing may mean less health supportive built environment
  - Lower quality housing
  - Fewer neighborhood 'amenities' such as sidewalks, grocery
  - Edges of the region
  - Locate next to less desirable uses such as freeways
- Cumulative impacts

  poor quality housing + poor indoor air quality + tobacco use in the house + working construction + etc…..

ODOT


Physical
Activity


Distribution of Onroad Benzene Concentrations along I-5 in N Portland
Axis of voume sources on I-5
Section 1
Section 2
Section 3
500 m
500 m
Concentration (ug/m3)
UTM (meters)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
522400
522600
522800
523000
523200
523400
523600
523800
524000
524200
524400
524600
524800
525000
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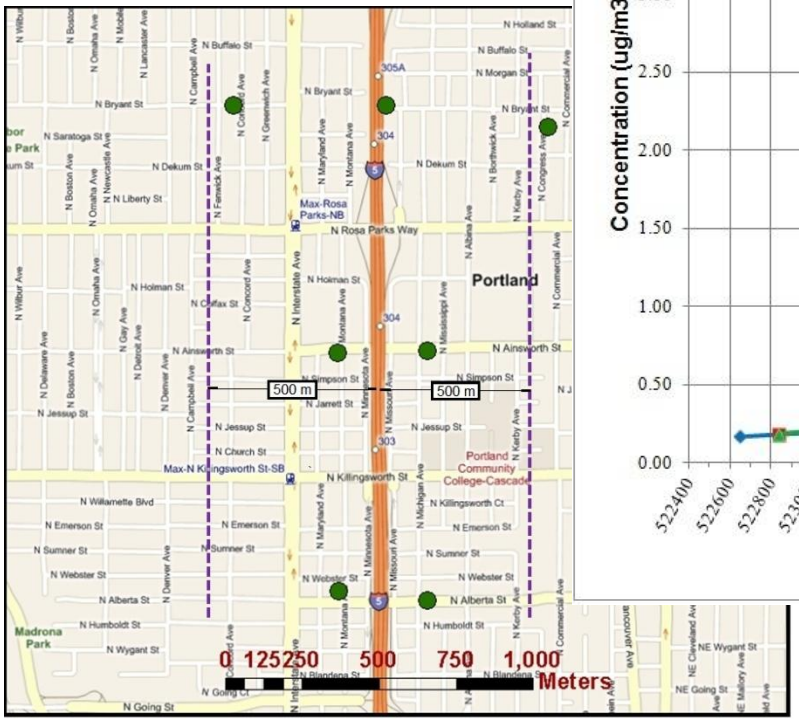
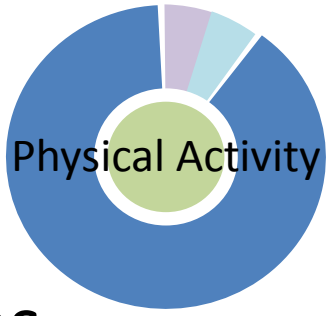
526600
526800
527000
527200
527400


Portland
500 m
500 m
0 125250 500 750 1,000
Meters

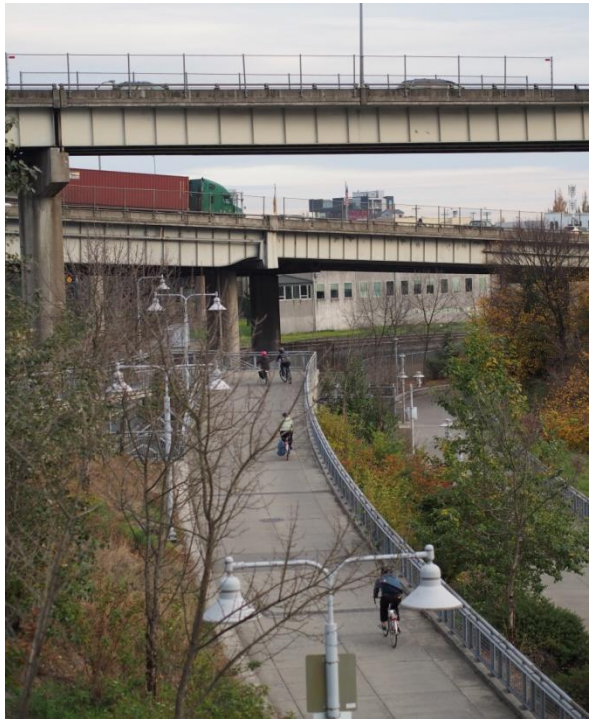
Source: DEQ

Land Use Matters



Thoughtful placement of bike/ped facilities

- Traffic Safety
- Individual exposure is a function of



Concentration in microenvironment → Not a huge difference between modes

+

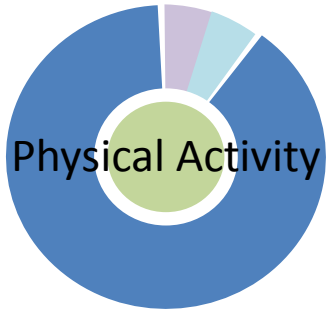
Time in micro environment

+

Respiratory Rates

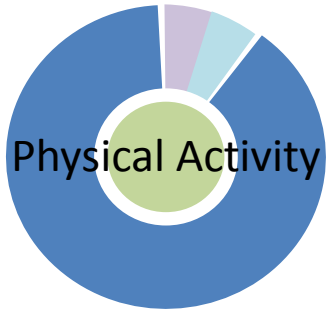
} Much higher for active modes

Physical Activity Summary



- Physical activity is both preventative and prescriptive for chronic disease
- Most health benefits in plan are from increased physical activity
  - 86-91% of avoided deaths
  - 69-84% of DALYs
- Active modes of transportation help meet 150 minutes per week goal

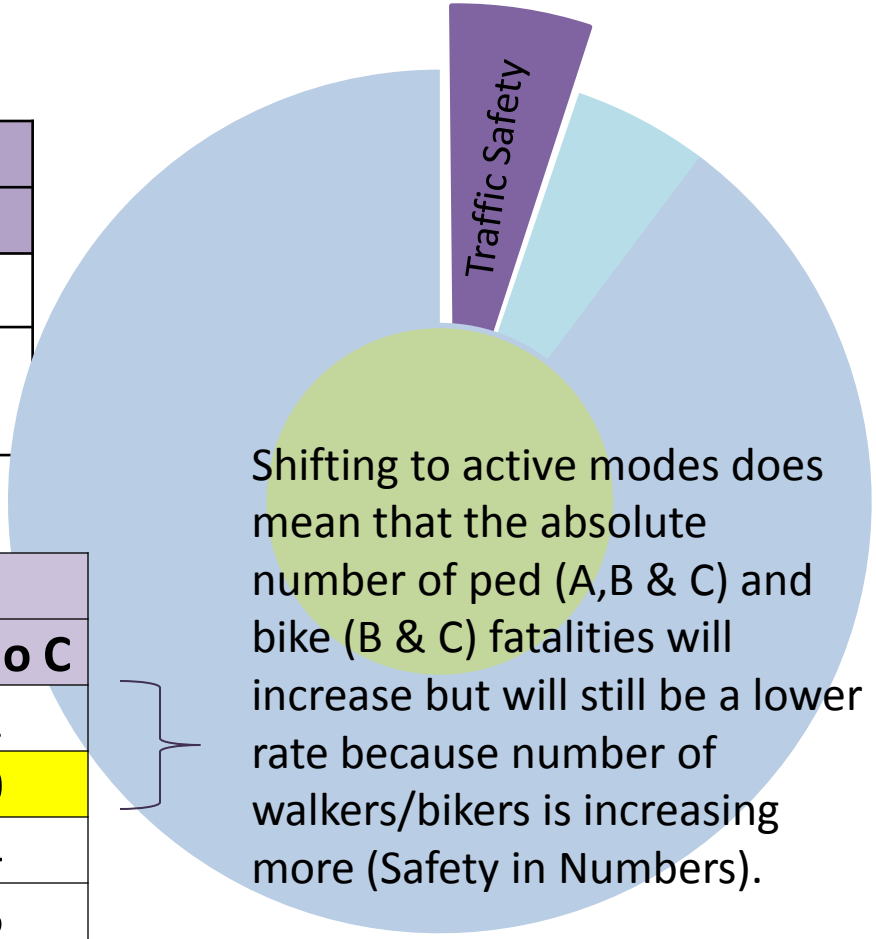
Physical Activity Summary



- Land Use Matters
  - Multi-modal investments
  - Low-income more likely to be transit dependent
    - Cumulative effects
    - Need to prioritize transit service
    - Careful about placement of affordable housing
  - Placement of bike/ped facilities
    - No difference in CONCENTRATION by mode
    - Big difference in INDIVIDUAL EXPOSURE by mode

ITHIM Results for Traffic Fatality

		Scenario		
		A	B	C
Avoided	Deaths	-1	-3	-10
	Percent of Scenario	*2%*	*5%*	*10%*



Mode	Relative Risk for Fatality		
	Scenario A	Scenario B	Scenario C
walk	1.08	1.07	1.01
cycle	0.98	1.13	1.20
car	0.93	0.86	0.74
mbike	0.99	0.98	0.96
total	0.99	0.96	0.89

Shifting to active modes does mean that the absolute number of ped (A,B & C) and bike (B & C) fatalities will increase but will still be a lower rate because number of walkers/bikers is increasing more (Safety in Numbers).

Overall decreased risk of traffic fatality

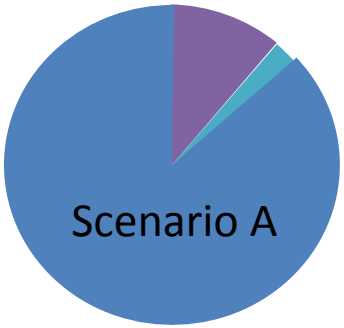
Traffic Fatalities

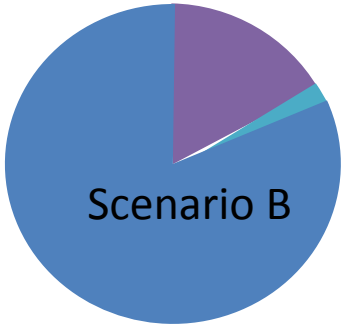
- **Value of a Statistical Life**
  - Summation of what a large number of people would each pay to reduce their chance of dying a tiny bit
- **DOT's default VSL is $9.1 million (in 2012$)** with a range of $5.2 to $12.9 million provided for sensitivity analyses (U.S. Department of Transportation, 2013).

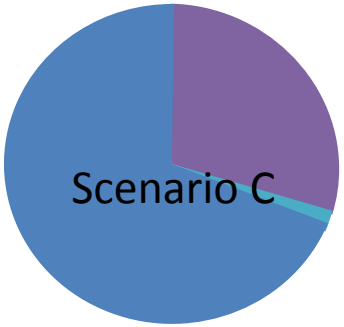
ITHIM Results for Traffic Injury

		Scenario		
		A	B	C
Avoided	YLL	-39	-116	-345
	YLD	-33	-67	-144
	DALY	-72	-183	-489
	Percent of Scenario	*13%*	*18%*	*30%*

Mode	Relative Risk for Serious Injury		
	Scenario A	Scenario B	Scenario C
walk	1.07	1.07	1.01
cycle	0.99	1.12	1.14
car	0.93	0.86	0.75
mbike	0.98	0.96	0.93
total	0.96	0.92	0.84





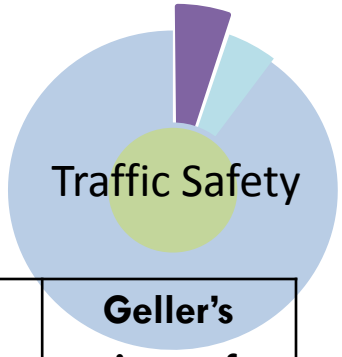


Traffic Safety: Value of an injury?

Level	Severity of Injury	Example	Prob of Death	Fraction of VSL	Assigned value (VSL= $9.1 mil)
AIS 1	Minor	superficial laceration	0	0.003	$27K
AIS 2	Moderate	fractured sternum	1 – 2	0.047	$428K
AIS 3	Serious	open fracture of humerus	8 – 10	0.105	$956K
AIS 4	Severe	perforated trachea	5 – 50	0.266	$2.4 mil
AIS 5	Critical	ruptured liver with tissue loss	5 - 50	0.593	$5.4 mil
AIS 6	Unsurvivable	total severance of aorta	100	1.000	$9.1 mil

U.S. DOT Abbreviated Injury Scale

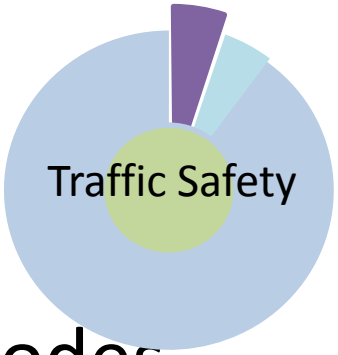
Value of Perceived Safety



	Description	City of Portland	Rest of region	All	Geller's estimate for City
Strong & Fearless	Very comfortable without bike lanes	6%	2%	4%	<1%
Enthused & Confident	Very comfortable with bike lanes	9%	9%	9%	7%
Interested but Concerned	Not very comfortable, interested in biking more Not very comfortable, currently cycling for transportation but not interested in biking more	60%	53%	56%	60%
No Way No How	Physically unable Very uncomfortable on paths Not very comfortable, not interested, not currently cycling for transportation	25%	37%	31%	33%
n (weighted)		436	479	915	

Source: Dill & McNeil (2012) Four Types of Cyclists

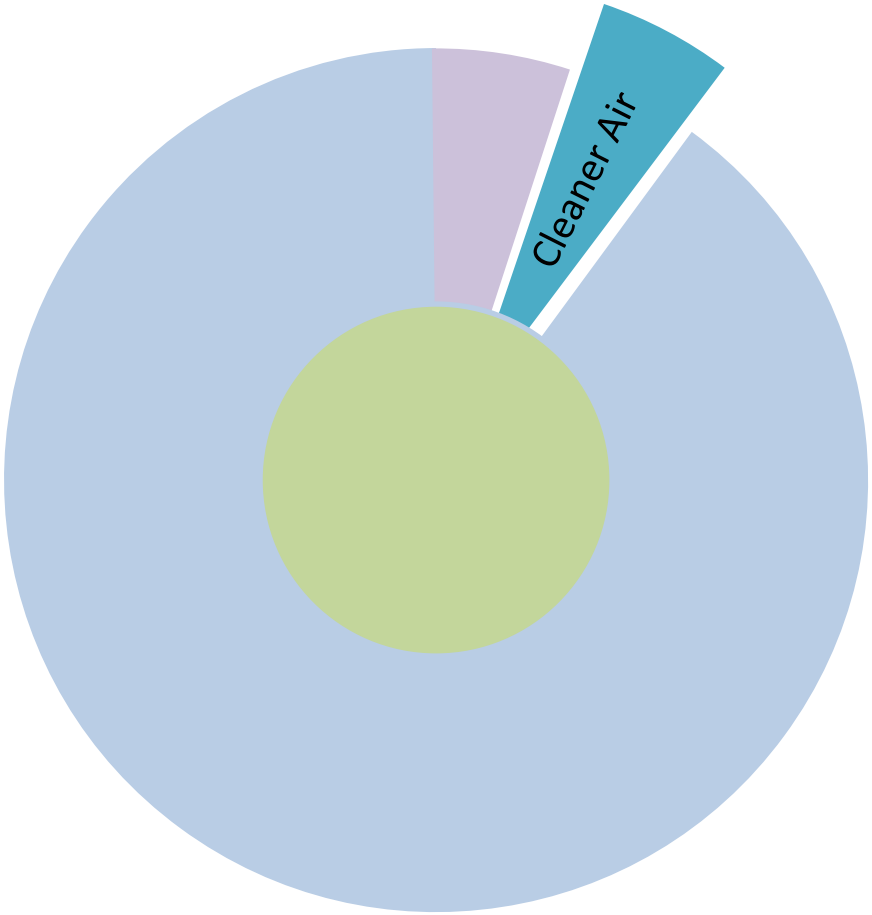
Traffic Safety Summary



- Shifting to more active transportation modes
  - Decreases the overall per-capital injuries and fatalities
  - Increases the ped/bike injuries
    - Need for mitigation and careful safety considerations
- Perceived safety is very important

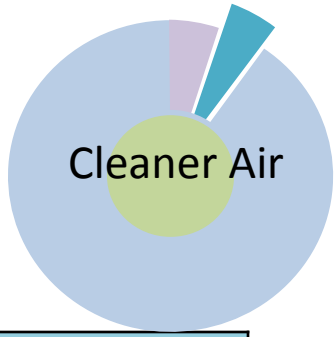
ITHIM Results for Air Quality

		Scenario		
		A	**B**	**C**
Decrease in PM2.5		2.8%	3.2%	3.6%
Avoided	**Deaths**	-3	-4	-4
	Percent of Scenario	*6%*	*5%*	*4%*
	YLL	-19	-22	-24
	YLD	0	0	0
	DALY	-19	-22	-24
	Percent of Scenario	*3%*	*2%*	*1%*



Note that ITHIM captures long-term exposure

Conditions of Concern



Health Outcome	PM ($PM_{2.5}$) 2009 ISA[1]	O_3 2013 ISA[2]	NOx (NO_2) 2008 ISA[3]
Short Term Exposure			
Respiratory Morbidity	●●●●	●●●●●	●●●●
Cardiovascular Morbity	●●●●●	●●●●	●●
Central Nervous System Morbidity	Not Reviewed	●●●	Not Reviewed
Mortality	●●●●●	●●●●	●●●
Long Term Exposure			
Respiratory Morbidity	●●●●	●●●●	●●●
Cardiovascular Morbidity	●●●●●	●●●	●●
Reproductive/Birth Outcomes	●●●	●●●	●●
Central Nervous System Morbidity	Not Reviewed	●●●	Not Reviewed
Cancer	●●●	●●	●●
Mortality	●●●●●	●●●	●●

Clean Air Act:
EPA to regulate criteria pollutants

- PM2.5
  - Fine particles emitted during combustion
  - Inhalation embeds deep within respiratory track
  - degrades health through systemic inflammation, oxidative stress, and altered heart and blood vessel function
  - Winter inversion days
- Ozone (ground-source)
  - Reaction from precursor chemicals emitted during combustion
  - Airway hyper responsiveness including increased permeability, oxidation and inflammation
  - Hot, summer days

Criteria Pollutants Health Pathways

$PM_{2.5}$ Exposure

Biological Mechanisms

Cardiovascular
Altered heart & vessel function

Cardiovascular & Respiratory
Systemic inflammation & oxidative stress

Morbidity Outcomes

Cardiovascular
(Hospitalizations, ER Visits)
- Ischaemic Heart Disease (IHD)
- Congestive Heart Failure (CHF)
- Stroke

Respiratory
(Hospitalizations, ER Visits)
- Chronic Obstructive Pulmonary Disease (COPD) and respiratory infections
- Asthma incidence

Suggestive Respiratory Effects
- Lung Cancer Incidence
- Intrauterine growth restriction (IUGR) and low birth weight

Pre-disposing Conditions

Cardiovascular or Respiratory Conditions, Asthma, Young Children, Older Adults

Mortality Outcomes

Cardiovascular | All Cause (0-1 day lag) | Respiratory | Lung Cancer

Ozone Exposure

Airway Hyperresonsiveness
↑ permeability, oxidation & inflammation
↓ resistance to respiratory and lung infections

Restricted lung growth& altered airway development in children

Systemic inflammation and oxidative stress

Respiratory Disease
Infections (pneumonia)
COPD (bronchitis, emphysema)
↑ Emergency Room Visits
↑ Hospital Admissions

Asthma
New Onset Incidence
Exacerbated Symptoms
↑ use of medication
↑ Emergency Room Visits
↑ Hospital Admissions

Cardiovascular Disease

Genotype, Asthmatics, Young Children, Older Adults Outdoor Workers

Respiratory | All Cause | Cardiovascular

Criteria Pollutants
Health Outcomes of Concern

Exposure	Broad Outcome	PM2.5	Ozone
Short-term (1-day lag)	Illness	ED and Hospitalizations for IHD, CHF, possibly respiratory	ED and Hospitalizations for asthma (new and recurring), infections, COPD (bronchitis)
	Death	Heart Attack	Respiratory
Long-term	Illness	Heart Disease Respiratory Disease Low-birth weight	Asthma (new and recurring) Respiratory & COPD
	Death	Cardiovascular & Lung-cancer	Respiratory

EPA NAAQS Rules

Pollutant [final rule cite]	Primary/ Secondary	Averaging Time	Level	Form
Ozone [73 FR 16436, Mar 27, 2008]	primary and secondary	8-hour	0.075 ppm [(3)]	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution $PM_{2.5}$ Dec 14, 2012	primary	Annual	12 µg/m^3	annual mean, averaged over 3 years
	secondary	Annual	15 µg/m^3	annual mean, averaged over 3 years
	primary and secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years

I thought Portland had clean air…

Portland is well within EPA NAQQS regulations for both PM and Ozone

- Long-term $PM_{2.5}$ = 7.4 (2009-2011)
- Few spikes of $PM_{2.5}$ above 35µg/m^3 or ozone above 0.075ppm

However for $PM_{2.5}$,

There is no level at which exposure to particulate matter ($PM_{2.5}$) is safe (WHO)

Linear dose-response, so reductions in $PM_{2.5}$ would be expected to have similar rates of reduction in death and disease.

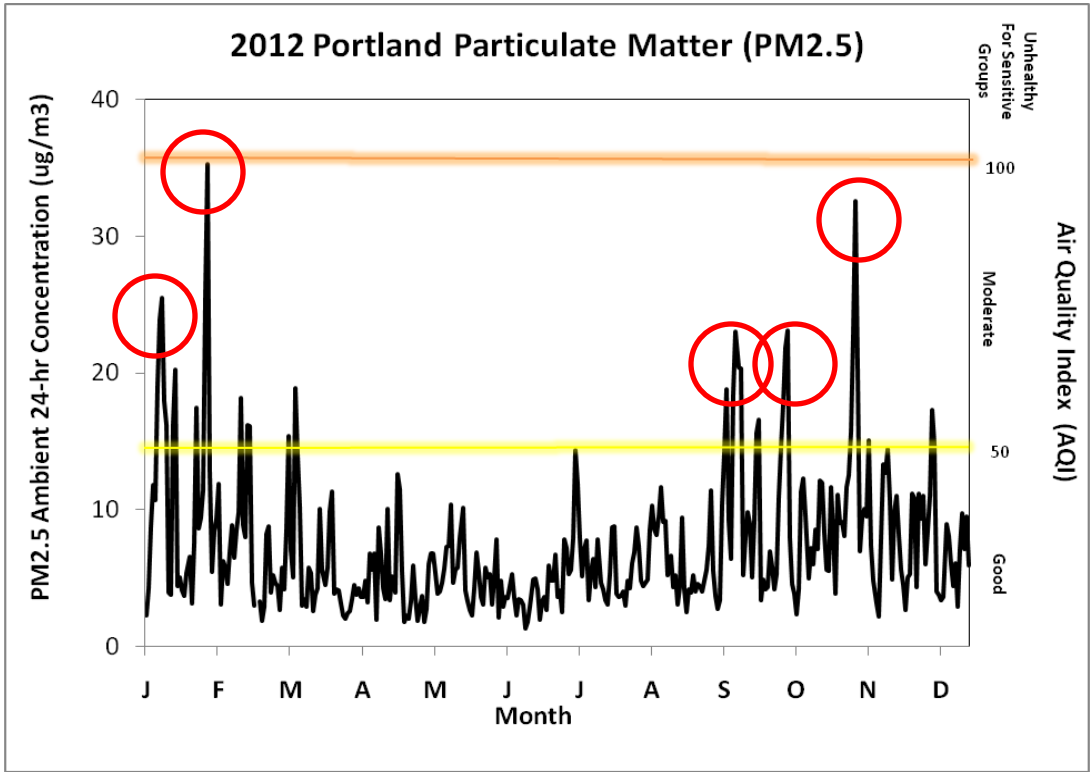
For Ozone

any threshold for which ozone does not degrade health "is likely to lie below 0.045ppm" and may be lower than even 0.035ppm (WHO)

$PM_{2.5}$ Episodes (Short-term)

Each circle, compared to well within 'good' is

- 30 heart attacks
- 1 death
- $40K per heart attack hospitalization



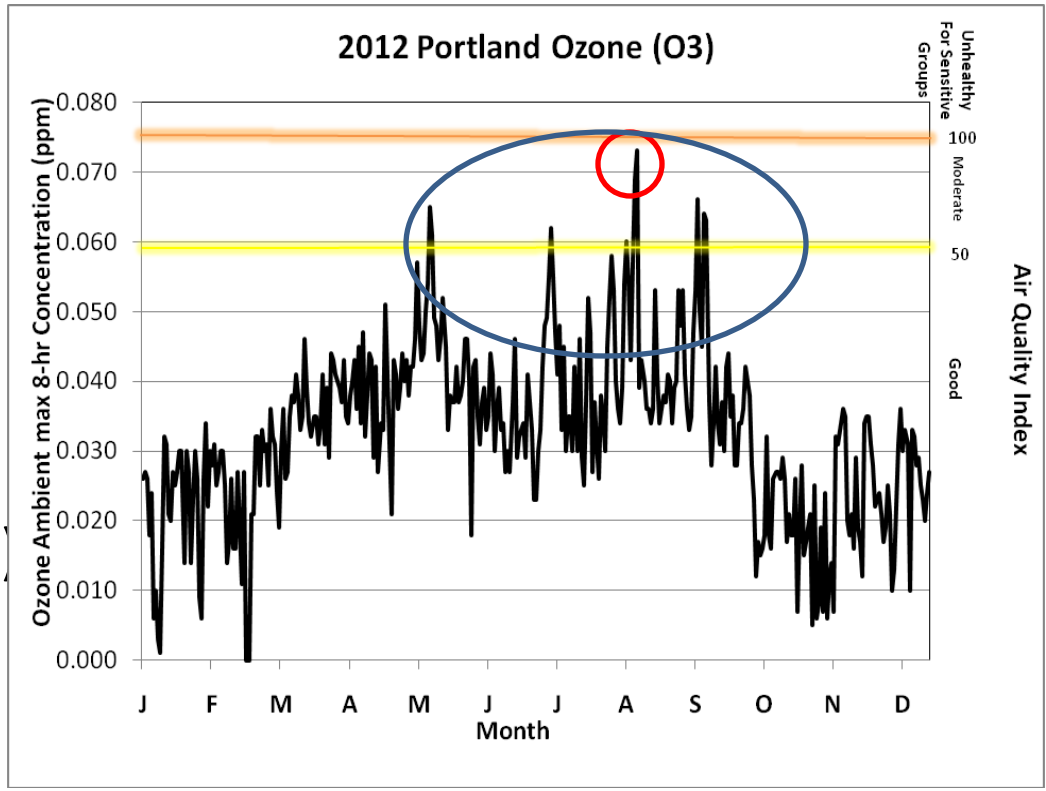
Ozone

Red Circle (Short term)

- 68% increase in child respiratory/asthma hospitalization

Blue Circle (Long-term in warm season

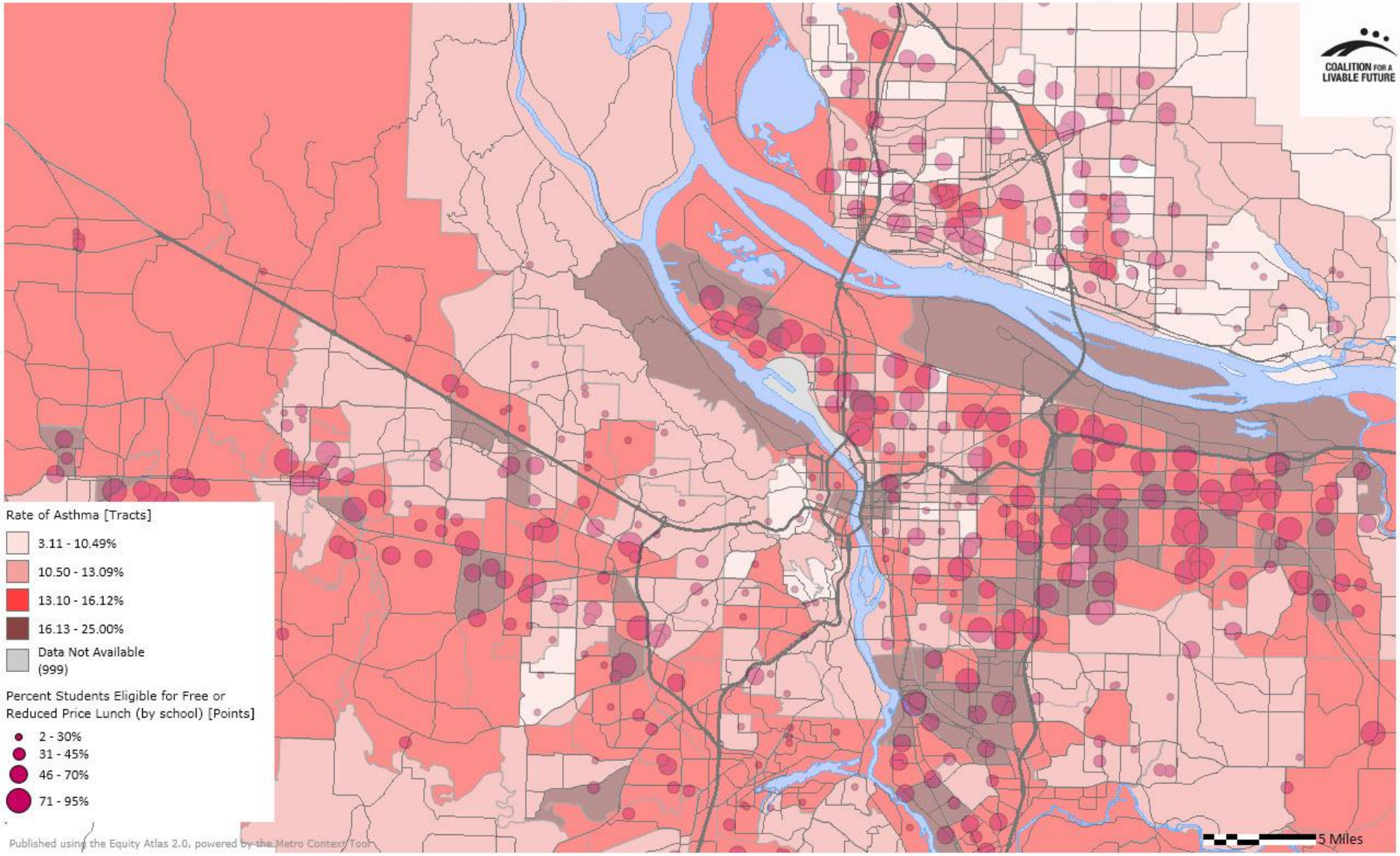
- Bringing down summer average 0.01 could result in ~18% decrease in child respiratory & asthma hospitalizations



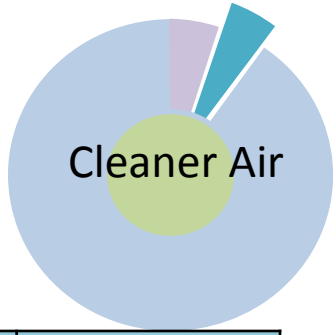
Asthma costs

- $14,300/hospitalization
- $15 mil in tri-county (2011)
  - $10 mil was OHP & Medicare

Asthma Rates in Relationship to % Students Eligible for Free or Reduced Price Lunch, Freeways and Arterial Streets



Air Toxics



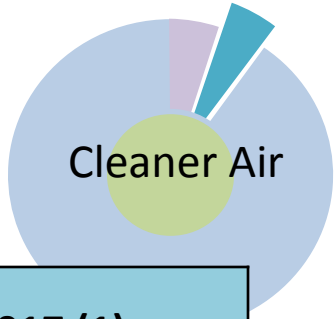
Pollutant	Health Effects	Toxicological Evidence - Animal (A) or Human (H)
ACROLEIN	General respiratory congestion; eye, nose, and throat irritation	A, H
ARSENIC	Known (Class A) Human Carcinogen (lung); irritation of skin and mucous membranes	A, H
BENZENE	Known (Class A) Human Carcinogen (leukemia); anemia, blood disorders, immune system damage	A, H
1,3-BUTADIENE	Probable Human Carcinogen (leukemia); cardiovascular disease	H
CHROMIUM VI	Known (Class A) Human Carcinogen (lung); repiratory tract damage and disease	H
ETHYL BENZENE	Respiratory irritation, central nervous system	A
FORMALDEHYDE	Probable (Class B1) Human Carcinogen (lung & nasal); respiratory irritation	H
NAPHTHALENE	Possible (Class C) Human Carcinogen; eye and retina damage	A, H
POLYCYCLIC AROMATIC HYDROCARBONS (PAH)	Varies depending on compound; 7 are Probable (Class B2) Carcinogens	

Air Toxics

Pollutant	Primary Cancer Type	Unit Risk
1, 3-Butadiene	Leukemia	3E-3 per $\mu g/m^3$ (0.08 per ppm)
Arsenic	Lung	4.3E-3 per 1 $\mu g/m^3$ (1)
Benzene	Leukemia, primarily acute myeloid	2.2E-6 to 7.8E-6 per 1 $\mu g/m^3$
Chromium VI	Lung	1.2E-2 per 1 $\mu g/m^3$

Source: http://www.epa.gov/iris/
(1) may increase in >2 $\mu g/m^3$ exposure settings

Air Toxics



Pollutant	PATS	State of Oregon Benchmark		Modeled 2017 (1)	
	ug/m3	ug/m3	% Reduction Required	% Attributable to On-Road Mobile	% Attributable to Light Duty
ACROLEIN	0.131	0.02	84.7%	3	1.9
ARSENIC	0.000558	0.0002	64.2%	28	10.1
BENZENE	0.956	0.13	86.4%	13	12.4
1,3-BUTADIENE	0.249	0.03	88.0%	64	56.3
CHROMIUM VI	0.000107	0.00008	25.2%	59	54.9
DIESEL PM	1.117	0.1	91.0%	16	0
ETHYL BENZENE	0.631	0.4	36.6%	32	30.4
FORMALDEHYDE	0.667	0.077	88.5%	8	5.0
NAPHTHALENE	0.159	0.03	81.1%	10	6.2
POLYCYCLIC AROMATIC HYDROCARBONS (PAH)	0.018	0.0009	95.0%	10	2.8-6.2

Source: Portland Air Toxics Report and DEQ

Air Quality Summary

Important air pollutants include

- $PM_{2.5}$ (Cardiovascular)
- Ozone (Respiratory)
- Air Toxics (Cancer)

Portland is largely within attainment of EPA $PM_{2.5}$ and Ozone regulations.

Work is needed to reach Air Toxic benchmarks.

There is **no safe level** of $PM_{2.5}$ (and the level considered safe for Ozone is well below current standards.