Environment

Contents

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Air Quality

Vehicle Miles Travelled (VMT)

Measure at a glance	
Category: *Environment* ***Subcategory:*** *Air Quality*	

Indicator Overview

Description

Vehicle miles travelled (VMT) is a measure of the number of miles driven on roadways in a specified area and period of time. Estimates of VMT are generally approximations of actual vehicle miles traveled, based on estimates of trip distance and frequency (Salon et al. 2012). VMT could be precisely measured using car odometers, but rarely is because of the difficulty in obtaining the information (Salon et al. 2012) and the challenge of determining where the vehicle travel occurred.

Human and Environmental Drivers

VMT is influenced by a complex set of interconnected factors and synergies between individual factors. For example, higher fuel prices reduce regional VMT, but the response at the household level is influenced by household location and income (Salon et al. 2012, 2013). Nationally, VMT has generally increased as the population has grown, the economy has expanded, and car ownership has increased. The Federal Highway Administration (FHWA) forecasts suggest that nationwide VMT will continue to grow by 1.07% annually through 2035. The FHWA forecast is influenced by projections for population growth, economic growth, and disposable income, all of which are positively associated with VMT (FHWA 2017). Literature on the effect of policy actions on VMT is challenging because the research often focused more on the direct impacts of the policy than VMT (Salon et al. 2012). Below is a mid-level summary of some factors associated with increases and decreases in VMT.

Factors associated with reductions in VMT:

1) Concentration of development into centers and mixed-use development patterns: Increasing accessibility to amenities decreases VMT. A 10 percent increase in population centrality decreases VMT by 1.5 percent (Bento et al. 2005). Mixed-use development decreases the required travel distance between residences and amenities and work, which can decrease VMT.

2) Public transit: Increased availability of public transit is associated with decreased VMT, but the effect is generally reported to be small (Hymel 2014).

3) Rising unemployment rates: Job loss reduces trip demand and VMT, however the effect is relatively small. A 1 percent increase in the unemployment rate results in a 0.1 percent decrease in VMT per adult (Hymel 2014).

4) Increased fuel price: Vehicle use and VMT tend to decrease as operating costs increase. A 50 percent increase in fuel prices leads to 5 percent decrease in VMT per adult in the short run and a 7.5 percent decrease in the long run (Hymel 2014).

5) Congestion: Traffic congestion increases travel time and the cost of trips. Higher levels of congestion inhibit trip generation and can reduce VMT.

6) Information and Incentive programs: The Programs often report large effects on VMT (48 percent to 90 percent reductions) for included individuals, but often suffer from selection bias because the programs are voluntary (Salon et al. 2012). Types of programs include, offering work-from-home flexibility and education and outreach to promote behavioral change (Salon et al. 2012).

Factors associated with increased VMT:

1) Increased roadway capacity: Greater roadway capacity increases VMT in the short and long term (Duranton & Turner 2011; Handy 2015).

2) Population growth: VMT generally increases as population increases. However, since 2000, population has grown faster than VMT (SACOG 2016a).

3) Increased per-capita income: Higher incomes increase demand to participate in social and economic activity outside of the house, which increases travel demand. Estimates suggest that in California, a 50 percent increase in income per adult leads to a 15 percent increase in VMT per adult in the short run and a 23 percent increase in the long run (Hymel 2014). However, the interaction between income and VMT is complex. Increased incomes also increase the "effective cost" of time spent travelling which reduces demand. VMT for households with incomes under $25,000 is less than a third of that for households with income above $100,000 (Salon et al. 2012).

4) Improved vehicle fuel economy: Estimates suggest a 50 percent decrease in fuel-intensity (fuel required to drive a mile) increases VMT per adult by 6 percent in the short-term and by 9 percent in the long-term (Hymel 2014).

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Application
In the Basin
TRPA adopted a VMT-based threshold standard in 1981 to reduce nitrate deposition on Lake Tahoe. The text of the adopted standard is, "Reduce vehicle miles of travel in the Basin by 10 percent of the 1981 base year values." "Regional Daily Vehicle Miles Traveled per Capita, Excluding Through Trips" is a TRPA Regional Plan Performance Measure that excludes VMT from trips that begin and end outside the Tahoe Basin. VMT is also used in the Basin to estimate greenhouse gas emissions from mobile sources.
External uses
Federal Highway Administartion: Includes VMT in its annual reports as a measure of infrastructure utilzation. VMT is reported among a suite of measures to assess federal highway system performance and apportion federal highway funds. **State of California:** SB743 suggests the use of VMT based measures (eg, VMT, VMT per capita) as alternatives to LOS for assessing impacts relative to the goals of "promote the reduction of greenhouse gas emissions, the development of multimodal transportation networks, and a diversity of land uses(OPR 2013)." **State of Washington:** Climate change. Used to set greenhouse gas reduction targets, consistent with executive order 07-02, and the implementation of RCW 47.04.280 and 47.01.078(4). A number of MPOs, including **Capital Area Metropolitan Planning Organization (Austin, TX), Denver Regional Council of Governments, Sacramento Area Council of Governments, Metropolitan Transportation Commission (San Francisco Bay Area), Metro (Portland, OR), Puget Sound Regional Council (Seattle, WA),** have established goals to reduce VMT per capita or VMT per household (Ecola & Wachs 2012).
Literature or Guidance Documents
The Partnership for Sustainable Communities, an interagency partnership of the U.S. Departments of Housing and Urban Development, Transportation, and Environmental Protection Agency, suggests that land use and transportation policy can be coordinated to reduce per capita VMT, but reducing total VMT may be challenging as a result of population growth and economic growth (PFSC 2017).
Relationship with Goal
Nitrogen: TRPA's threshold standard for VMT was established in 1982 as a proxy for nitrate deposition into Lake Tahoe (TRPA 1982). At the time, it was believed that increased algal growth was primarily responsible for Lake Tahoe's declining clarity (TRPA 1982). The TMDL identified atmospheric deposition as the primary source of nitrogen reaching the lake (Lahontan & NDEP 2010b). Atmospheric deposition was estimated to account for 55 percent of the nitrogen reaching the lake (Lahontan & NDEP 2010b). Emissions from on-road mobile sources are estimated to account for between 37 percent and-46 percent of nitrogen emissions in the Tahoe Basin (CTC 2016). Vehicle emissions have improved significantly as a result of vehicle emissions standards and technological advances (EPA 2017a). As emissions from automobiles have changed, the relationship between VMT and NOx emissions has evolved. On average, NOx emissions have decreased from 3.6 grams/mile in 1955 to 0.217 grams/mile in 2013, and are forecast to be 0.13 grams/mile in 2020. **Water Quality:** The Lake Tahoe Total Maximum Daily Load (TMDL) is a science-based plan to restore Lake Tahoe's famous water clarity. Science compiled for the TMDL improved knowledge about the causes of declining lake clarity. The TMDL identified fine sediment particles (FSP) as the primary pollutant responsible for declining clarity in the lake and found increased FSP concentrations are responsible for nearly two-thirds of clarity loss (Lahontan & NDEP 2010a, 2010b). The TMDL also identified urban upland environments as the source of 72 percent of FSP pollution (Lahontan & NDEP 2010b). The TMDL identified light absorption by phytoplankton as a secondary driver responsible for a third of clarity loss. Phosphorus and nitrogen are nutrients responsible for increased algal growth. To achieve the clarity goal agreed upon by the two states, the TMDL identified pollutant load reductions of 65 percent for FSP, 35 percent for phosphorus, and 10 percent for nitrogen (Lahontan & NDEP 2010b). **Fine sediment particles:** There is no direct relationship between VMT and FSP from roadways. FSP from roads are primarily influenced by road operations management practices and the application of winter traction material (Zhu et al. 2009). FSP from roadways are on average five times higher in the winter than they are in the summer, and can be 10 times higher following the application of winter traction material (Zhu et al. 2009). VMT patterns in the basin are marked by an inverse seasonality pattern of FSP from roads. Summertime VMT is 40 percent to 50 percent higher than wintertime VMT. **Greenhouse Gas Emissions (GHG):** GHG emissions from mobile sources are a function of VMT, vehicle fleet characteristics, and fuel carbon content. Many transportation planning agencies use VMT to track and target changes in emissions because

they can influence VMT, but do not regulate vehicle technologies and fuels. Reliance on VMT to estimate mobile GHG emissions has been criticized because VMT does not account for congestion (UCLA 2009).

Human Health: High concentrations of pollutants originating from automobiles and trucks exceeding ambient state and federal air quality standards are known to cause undesirable health impacts.

Safety: VMT is often used to normalize and compare the number of accidents, injuries, and fatalities on roadways with highly variable traffic volumes.

Congestion: Congestion occurs when the number of vehicles on a roadway exceeds roadway capacity. While both VMT and congestion are related to roadway utilization, the relationship between the two is complex. Additional cars on the road generally increases VMT and leads to congestion. Congestion can result in decreased VMT as trip duration and the effective cost of travel increases, reducing trip generation (Brownstone 2008; UCLA 2009).

Variations of the Measure / Alternatives to the measures

VMT based measures can include many different variants, including: 1) Time adjusted (time of day or week); 2) Population adjusted (per-capita or regional per capita VMT); 3) Use adjusted (commute VMT or VMT per employee); 4) Population type adjusted (community type, driver age); 5) Vehicle type (automobile, light duty truck); and 6) Condition based (such as congested VMT, which measures VMT during periods when roadways are classified as congested). For each of the variants, VMT is calculated as the total miles of vehicle travel divided by the population around interest. Individual agencies often use multiple variations or combinations of these factors to understand trends or evaluate more specific goals in VMT. Different variants of VMT based measures can provide information into the source of VMT generation and enable more targeted policy solutions to reduce VMT or congested VMT. For example, SACOG tracks, 1) Total weekday VMT and average annual growth rates regionally, by county, and per capita, 2) Weekday VMT by source and total, 3) Weekday VMT by source per capita or per job 4) Total VMT per capita, 5) Percent change in VMT per capita or per job compared to 2012, 6) Weekday household-generated VMT per capita by community type, 7) Weekday household-generated VMT per capita by TPA, 8) Household-generated commute VMT by community type and regional total, 9) Commute VMT per worker by community type and regional total, 10) Congested VMT total and per capita, 11) Congested VMT by source, total, per capita, and per job, 12) Congested VMT for household-generated travel by community type.

References

(Bento et al. 2005)
(Brownstone 2008)
(Ecola & Wachs 2012)
(EPA 2017a).
(Handy 2015).
(Hymel 2014)
(Lahontan & NDEP 2010a).
(Lahontan & NDEP 2010b)
(SACOG 2013)
(SACOG 2016b)
(Salon et al. 2012)
(UCLA 2009)
(TRPA 1982).
(Zhu et al. 2009)

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Greenhouse Gas Emissions

Measure at a glance	
Category: Environment ***Subcategory:*** Air Quality	

Indicator Overview

Description

This indicator measures the amount of greenhouse gases known to absorb and trap radiation that are released into the atmosphere. Emissions are generally expressed in tons of carbon dioxide equivalent (CO2-e) released into the atmosphere.

Human and Environmental Drivers

Anthropogenic GHG emissions are a function of population size, economic activity, lifestyle, energy use, land use patterns, technology, and climate policy *(IPCC 2015)*. Electricity consumption, natural gas consumption, and transportation activities contribute approximately 75 percent of GHG emissions in the Lake Tahoe Region *(CTC 2012)*. On-road transporation is estimated to be the source of about 22 percent of regional greenhouse gas emissions *(CTC 2012)*.

Application

In the Basin

TRPA uses a “Greenhouse Gases Reduced” measure within the EIP Performance Measures (TRPA 2017). “Greenhouse Gases Reduced” measures the volume of greenhouse gases sequestered or emissions avoided as a result of project implementation.

External uses

State of California: Assembly Bill 32 and Senate Bill 375 established GHG reduction targets to be met through integrated land use and transportation planning.

United Nations Framework Convention on Climate Change (UNFCCC): Use GHG emissions to track countries’ commitments under the Paris climate accord.

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Air Quality: Increasing concentrations of greenhouse gases in the atmosphere are the primary cause of climate change. Total emissions of greenhouse gases will largely determine the extent to which the earth will warm (IPCC 2015). Greenhouse gas emissions are the measure of the release of greenhouse gases within a region.

Variations of the Measure / Alternatives to the Measures

GHG emissions are generally reported either as the total amount of GHG emitted (expressed as weight) or as weight of emissions adjusted per capita in the region of interest. Carbon dioxide is also a variation of greenhouse gas emissions, which focuses on a single greenhouse gas.

References

(CTC 2012)

(IPCC 2015)

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Carbon Monoxide (CO)

Measure at a glance	
Category: Environment ***Subcategory:*** Air Quality	

Indicator Overview

Description

This indicator measures the concentration of carbon monoxide (CO) in a defined location, such as the Tahoe Basin. Carbon monoxide is a tasteless, odorless, and colorless gas. It is a public health concern because elevated concentrations affect human and animal health by reducing the supply of oxygen to body tissues.

Human and Environmental Drivers

Carbon monoxide is created through the incomplete combustion of carbon-based fuels. The primary anthropogenic sources of carbon monoxide are on-road motor vehicles (30 percent), residential wood burning (28 percent), motorized watercraft (16 percent), and off-highway vehicles (8 percent) (California Air Resources Board 2006). Wildfires are a natural source of carbon monoxide. Meteorology also plays a key role in the concentration of carbon monoxide within the Tahoe Region as wind and inversion layers can affect concentrations.

Vehicle emission standards enacted by state and federal governments have also reduced CO emissions in the Region, mainly by requiring improvements in engine and exhaust technologies.

Application

In the Basin

TRPA has one threshold standard that directly relates to carbon monoxide concentrations, "Maintain carbon monoxide concentrations at or below 6 parts per million (7 mg/m3) averaged over 8 hours."

External uses

Ambient carbon monoxide concentrations are part of state and federal air quality regulations. Federal regulations for carbon monoxide are part of the EPA established National Ambient Air Quality Standards (NAAQS). Additional information on NAAQS can be found at: https://www.epa.gov/criteria-air-pollutants/naaqs-table. California and Nevada have established standards for carbon monoxide. Information on state standards can be found at https://www.arb.ca.gov/research/aaqs/aaqs2.pdf and https://ndep.nv.gov/air/air-quality-monitoring/ambient-air-quality-standards respectively.

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

The measure is a direct measure of the concentration of a pollutant known to adversely impact human and environmental health.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

Ozone

Measure at a glance

Category: Environment
Subcategory: Air Quality

Indicator Overview

Description

This indicator measures the concentration of ozone (O3) in a defined region such as the Tahoe Basin. Ozone is created through a photochemical reaction between atmospheric oxygen, hydrocarbons and/or carbon monoxide, oxides of nitrogen, and sunlight. At high concentrations at ground level in the lower atmosphere, ozone is an air pollutant that can harm the respiratory systems of people and animals and damage plant tissue. Young and elderly people are especially susceptible to elevated ozone levels, which can cause lung and other respiratory illnesses. Ozone damages trees and plants, particularly ponderosa pines, Jeffrey pines, and quaking aspen that make up a large portion of the Tahoe Basin's tree population (Davis and Gerhold 1976).

Human and Environmental Drivers

Ozone is considered a secondary pollutant, created by photochemical reactions between hydrocarbons (HC) and oxides of nitrogen (NOx) in sunlight. The sources of HC and NOx include mobile sources (cars, trucks, boats, aircraft, off-road vehicles, etc.), biomass burning (wood stoves, wildfires, prescribed burning), and consumer products such as solvents. Ozone is transported from populated areas around the Lake Tahoe Region into the basin, and the ambient ozone concentration is highly dependent on meteorological conditions such as sunlight, temperature, wind speed, and mixing conditions.

The primary sources of ozone precursor gases in the Lake Tahoe Basin include on-road motor vehicles, residential fuel combustion, motorized watercraft, off-road equipment, solvent and fuel evaporation, and off-road recreational vehicles (California Air Resources Board 2006). Ozone can also be transported into the Lake Tahoe Basin from outside sources, although these sources are reported not to substantially contribute to overall ozone concentrations (CARB 2004). Research into the amount of ozone transport from outside sources is ongoing. Because ozone formation is a photochemical process, higher concentrations are created on cloud-free summer days when the sun's radiation is at its peak.

Application

In the Basin

TRPA has one threshold standard that directly relates to ozone concentrations: "Maintain ozone concentrations at or below 0.08 parts per million averaged over 1 hour."

External uses

Ambient ozone concentrations are part of state and federal air quality regulations. Federal regulations for ozone are part of the EPA established National Ambient Air Quality Standards (NAAQS). Additional information on NAAQS can be found at: https://www.epa.gov/criteria-air-pollutants/naaqs-table .Both the states of California and Nevada have established standards for ozone. Information on state standards can be found at https://www.arb.ca.gov/research/aaqs/aaqs2.pdf and https://ndep.nv.gov/air/air-quality-monitoring/ambient-air-quality-standards respectively.

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

This measures the concentration of a pollutant known to adversely impact human and environmental health.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(TRPA 2012a)

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Nitrogen Dioxide

Measure at a glance	
Category: Environment ***Subcategory:*** *Air Quality*	

Indicator Overview

Description

This indicator measures the concentration of nitrogen dioxide (NO2) in a location such as the Tahoe Basin. Nitrogen dioxide is one of a group of highly reactive gasses known as “nitrogen oxides.” Other nitrogen oxides include nitrous acid and nitric acid. While federal standards cover the entire group of nitrogen oxides, Nitrogen dioxide is the component of greatest interest and the indicator for the larger group of nitrogen oxides. In addition to contributing to the formation of ground-level ozone and fine particle pollution, nitrogen dioxide is linked with regional haze, global warming, water quality degradation, and multiple adverse effects on the respiratory system (EPA 2011c).

Human and Environmental Drivers

The primary source of nitrogen dioxide is the combustion of fossil fuels *(EPA 2017b)*.

Application

In the Basin

No current in-basin use.

External uses

Ambient nitrogen dioxide concentrations are part of state and federal air quality regulations. Federal regulations for nitrogen dioxide are part of the EPA established National Ambient Air Quality Standards (NAAQS). Additional information on NAAQS can be found at: https://www.epa.gov/criteria-air-pollutants/naaqs-table. Both the states of California and Nevada have established standards for nitrogen dioxide. Information on state standards can be found at https://www.arb.ca.gov/research/aaqs/aaqs2.pdf and https://ndep.nv.gov/air/air-quality-monitoring/ambient-air-quality-standards respectively.

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

This measures the concentration of a pollutant known to adversely impact human and environmental health. Current scientific evidence links short-term nitrogen dioxide exposure ranging from 30 minutes to 24 hours with adverse respiratory effects, including airway inflammation in healthy people, and increased respiratory symptoms in people with asthma (EPA 2011b).

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(EPA 2017b)
(EPA 2011a)
(EPA 2011b)

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Particulate Matter (PM)

Measure at a glance

Category: Environment
Subcategory: *Air Quality*

Indicator Overview

Description

This indicator measures the concentration of particulate matter (PM) in a region such as the Tahoe Basin. Atmospheric particulate matter consists of very small liquid and solid particles, designated PM10 for particulate matter less than 10 microns in diameter and PM2.5 for particulate matter less than 2.5 microns in diameter. PM10 is among the most harmful of air pollutants. When inhaled, the particles disrupt the respiratory system's natural defenses and lodge deep in the lungs. PM10 can increase the number and severity of asthma attacks and cause or aggravate bronchitis. PM2.5 is the primary cause of haze *(EPA 2016a)*.

Human and Environmental Drivers

The main sources of particulate matter in the Tahoe Basin are residential and wildfire smoke and entrained roadway dust (DRI 2011a).

Application

In the Basin

TRPA has four threshold standards that directly relate to particulate matter;

1) Particulate Matter 10 24-hour Standard: Maintain Particulate Matter 10 at or below 50µg/m3 measured over a 24-hour period in the portion of the Region within California, and maintain Particulate Matter 10 at or below 150 µg/m3 measured over a 24-hour period in the portion of the Region within Nevada. Particulate Matter10 measurements shall be made using gravimetric or beta attenuation methods or any equivalent procedure which can be shown to provide equivalent results at or near the level of air quality standard.
2) Particulate Matter 10 Annual Arithmetic Average: Maintain Particulate Matter 10 at or below annual arithmetic average of 20µg/m3 in the portion of the Region within California, and maintain Particulate Matter 10 at or below annual arithmetic average of 50µg/m3 in the portion of the Region within Nevada. Particulate Matter 10 measurements shall be made using gravimetric or beta attenuation methods or any equivalent procedure which can be shown to provide equivalent results at or near the level of air quality standard.
3) Particulate Matter 2.5 24-hour Standard: Maintain Particulate Matter 2.5 at or below 35µg/m3 measured over a 24-hour period using gravimetric or beta attenuation methods or any equivalent procedure which can be shown to provide equivalent results at or near the level of air quality standard.
4) Particulate Matter2.5 Annual Arithmetic Average - Maintain Particulate Matter2.5 at or below annual arithmetic average of 12µg/m3 in the portion of the Region within California and maintain Particulate Matter2.5 at or below annual arithmetic average of 15µg/m3 in the portion of the Region within Nevada. Particulate Matter2.5 measurements shall be made using gravimetric or beta attenuation methods or any equivalent procedure which can be shown to provide equivalent results at or near the level of air quality standard.

External uses

Ambient particulate matter for both PM10 and PM2.5 concentrations are part of state and federal air quality regulations. Federal regulations for PM are part of the EPA established National Ambient Air Quality Standards (NAAQS). Additional information on NAAQS can be found at: https://www.epa.gov/criteria-air-pollutants/naaqs-table. Both the states of California and Nevada have established standards for PM. Information on state standards can be found at https://www.arb.ca.gov/research/aaqs/aaqs2.pdf and https://ndep.nv.gov/air/air-quality-monitoring/ambient-air-quality-standards respectively.

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Air Quality: The indicator directly measures the concentration of two pollutants known to adversely impact human and environmental health.

Variations of the Measure / Alternatives to the Measures

No variations identified.

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References
(EPA 2016a) (EPA 2016b)

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Visibility

Measure at a glance

Category: Environment
Subcategory: *Air Quality*

Indicator Overview

Description

"Visibility" measures regional visibility and the distance that the human eye can see. It is measured by using a reconstructed light extinction (bext) value, which is derived from an equation that combines measured concentrations of several gases and particles. The equation is corrected for humidity and natural background light scattering. Bext is summarized by "average visibility days" (50th percentile values) and "worst visibility days" (90th percentile values) for each year, followed by calculating the three-year running average. This threshold standard has been adopted to protect regional visibility and air quality.

Human and Environmental Drivers

Visibility is directly influenced by light scattering and absorption which is the measured by the extinction coefficient. Particulate matter in the atmosphere is the primary driver of visibility impairment because of the optical properties and long retention times in the air (Green et al. 2011, 201). The main sources of particulate matter in the basin are residential and wildfire smoke and entrained roadway dust (DRI 2011a). Effective motor vehicle tail pipe emission controls, residential wood combustion controls, appropriately managed prescribed burning, and road dust emission control aid in improving regional visibility conditions (Chen, Watson, and Wang 2011).

Application

In the Basin

TRPA has four threshold standards that measure visibility, two for regional and two for sub regional visibility (TRPA 2012a).

Regional Visibility

1) Achieve an extinction coefficient of 25 Mm-1 at least 50 percent of the time as calculated from aerosol species concentrations measured at the Bliss State Park monitoring site (visual range of 156 kilometer, 97 miles); and
2) Achieve an extinction coefficient of 34 Mm-1 at least 90 percent of the time as calculated from aerosol species concentrations measured at the Bliss State Park monitoring site (visual range of 115 kilometers, 71 miles).

Subregional Visibility

3) Achieve an extinction coefficient of 50 Mm-1 at least 50 percent of the time as calculated from aerosol species concentrations measured at the South Lake Tahoe monitoring site (visual range of 78 kilometers, 48 miles); and
4) Achieve an extinction coefficient of 125 Mm-1 at least 90 percent of the time as calculated from aerosol species concentrations measured at the South Lake Tahoe monitoring site (visual range of 31 kilometers, 19 miles); and

Calculations will be made on three year running periods. Beginning with the existing 1991-93 monitoring data as the performance standards to be met or exceeded.)

External uses

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Air Quality: Extinction coefficient is a direct measurement of scattering and absorption of light through the air which measures how transparent or hazy the air appears to the human eye. This measure relates to air quality because visibility is correlated with the clarity of the air.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Green, Mark et al. 2011)
(Chen et al. 2011)
(Chen, L.-W. Antony et al. 2014)
(TRPA 2012a)

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Per Capita Fuel Consumption

Measure at a glance	
Category: Environment ***Subcategory:*** *Air Quality*	

Indicator Overview

Description

This indicator measures per capita consumption of fuels within a defined geography over a set period of time. The measure is reported as the total amount of fuel consumed within a specified time divided by the population of the geography.

Human and Environmental Drivers

Population size, car ownership, vehicle miles traveled, fleet mix and fuel efficiency, congestion, and speed/acceleration all contribute to per capita fuel consumption. Land use patterns, transit service, and active transportation options influence automobile usage.

Application

In the Basin

No current use in basin.

External uses

The **U.S. Energy Information Administration** measures "fuel consumption per capita" in its International Energy Outlook. (United States Energy Information Administration 2016).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Air Quality: This measure relates to the air quality goal because it measures the impact of fuel consumption, and therefore emissions per capita on the surrounding atmosphere. Consumption of oil based fuel produces large amounts of harmful toxins such as carbon monoxide and particulate matter into the atmosphere, heavily impacting air quality. The higher the consumption of fuel, the larger the negative impact is on the surrounding environment.

Operations and Congestion: Transit service and active transportation options influence automobile usage and total fuel consumption.

Connectivity: This measure relates to the connectivity goals of automobiles and transit because it analyzes ways in which both automobiles and transit can optimize fuel efficiency.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Ahn et al. 2002)
(Smit et al. 2008)
(United States Energy Information Administration 2016)

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Transit System Alternative Fuel Usage

Measure at a glance	
Category: Environment ***Subcategory:*** *Air Quality*	

Indicator Overview

Description

This indicator is a measure of the percent of transit fleet that runs on alternative fuels.

Human and Environmental Drivers

Environmental: Transit fleet mix is a product of investment decisions by the fleet operator. Transit fleet fuel consumption is dependent on factors of the passenger load, road grade, acceleration, and fuel type. Additionally, the weight of buses makes this transportation mode more prone to accruing low levels of fuel efficiency.

Economic: The decision to use a fuel type is often driven by economic considerations. Fossil fuels have historically been cheaper than alternatives fuel sources. Long-term analysis of the implementation of alternatively fueled transit systems has found that it can be more cost effective to invest in transit systems that use alternative fuels.

Application

In the Basin

No current in basin use.

External uses

Alameda-Contra Costa Transit District uses the "Transit System Alternative Fuel Usage" measure to understand the effectiveness of using hydrogen fuel cell-powered buses in its fleet (Alameda-Contra Costa Transit District 2017).

Literature or Guidance Documents

No literature of guidance documents identified.

Relationship with Goal

Air Quality: This measure relates to the air quality goal because it measures the propotion of transit fleet powered by low emissions fuels. Many bus fleets run on diesel fuel, releasing large amounts of hydrocarbon, particulate matter, and carbon monoxide into the air. Fleet conversion to low-emission fuels decreases pollutant emissions and improves air quality.

Connectivity: This measure relates to the transit-oriented goal because it directly analyzes means for increasing transit efficiency.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Ahouissoussi & Wetzstein 1998)

(Alameda-Contra Costa Transit District 2017)

(Eudy et al. 2010)

(Frey et al. 2007)

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Tree Canopy Percentage of Roadways	
Measure at a glance	
Category: Environment ***Subcategory:*** *Air Quality*	

Indicator Overview

Description

This indicator measures the percentage of roadways that are covered by trees. Increasing tree canopy is associated with higher air quality and has been shown to slow traffic.

Human and Environmental Drivers

Tree canopy coverage along roadways is a function of the natural environment the roadway was constructured through and the extent to which trees were cleared during construction or have been replanted since. As the number of trees within an area increases, the number of harmful vehicle emissions is mitigated through the absorption of harmful gases such as carbon dioxide. Tree canopy cover also cools the local enviroment, preventing further limiting the residence time of some toxins in the air. The aesthetic of trees return a more positive response from residents and visitors walking, bicycling, and driving.

Application

In the Basin

No current in-basin use.

External uses

Seattle Department of Transportation created a "Trees and Sidewalks Operations Plan" to emphasize the proper management of trees in the city (Seattle Department of Transportation 2015).
City and County of San Francisco Planning Department recognizes the need to reintegrate trees into the urban environment and created an Urban Forest Plan to monitor, maintain, and increase the total number of trees in the region (San Francisco Planning Department 2014).
New York City Parks Department manages a map of the New York City region's trees to provide the public with information about the total tree canopy in the area (New York City Parks Department).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Quality of Life: Greater tree cover is related to more positive perception of the landscape. In the urban environment, greater tree canopy is correlated with neighborhood desirability and higher home prices *(Schwarz et al. 2015)*.
Air Quality: This measure relates to the air quality goal because the effects of trees on pollutants in the atmosphere act as a direct buffer between toxic emissions and their impact on environmental and human health. As the number of trees within an area increases, harmful vehicle emissions are mitigated through the absorption of harmful gasses such as carbon dioxide. Through trees ability to process and filter these toxins, air quality is generally improved. Many harmful gases need heat to survive, so the urban forest's cooling impacts automatically limit the amount of toxins possible in the air.
Safety: Studies have indicated that the presence of trees relaxes drivers, reduces speeding, and increases driver awareness, which reduces the number of accidents. The measure assesses the presence of a condition that is correlated with safer driving and is thus an indirect measure of safety.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Dixon & Wolf 2007)

(Nowak et al. 2014)

(Nowak & Heisler 2010)

(New York City Parks Department n.d.)

(San Francisco Planning Department 2014)

(Seattle Department of Transportation 2015)

(Schwarz et al. 2015)

(USDA Forest Service 2002)

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Noise

Ambient Noise

Measure at a glance

Category: Environment
Subcategory: *Noise*

Indicator Overview

Description

This indicator measures the background noise levels and is measured in community noise equivalent level (CNEL). CNEL is a noise measurement based on a weighted average of all measured noise over a period of time.

Human and Environmental Drivers

Environmental: Ambient noise levels are a function of all natural and anthropogenic sources of noise audible from the listening location. Anthropogenic noise sources include on-highway vehicles, off-highway vehicles, construction, over-snow vehicles, watercraft, and aircraft. Natural source of noise includes streams, wind, storms, rock falls, and animals.

Application

In the Basin

TRPA has nine threshold standards for ambient noise levels in land use categories(TRPA 2012a, 2012b);

1) High Density Residential Areas
2) Low Density Residential Areas
3) Hotel/Motel Areas
4) Commercial Areas
5) Industrial Areas
6) Urban Outdoor Recreation Areas
7) Rural Outdoor Recreation Areas
8) Wilderness and Roadless Areas
9) Critical Wildlife Habitat Areas

TRPA has an additional seven threshold standards for ambient noise levels in land use categories;

1) South Lake Tahoe Airport Transportation Corridor
2) State Route 28 Transportation Corridor
3) Highway 50 Transportation Corridor
4) State Route 89 Transportation Corridor
5) State Route 207 Transportation Corridor
6) State Route 267 Transportation Corridor
7) State Route 431 Transportation Corridor

CNEL for these categories are evaluated using all measured noise over a 24-hour period. The CNEL indicator applies a +4.77dB (decibel) “penalty” or weight to noise levels during the evening period of 7 p.m. to 10 p.m. and a +10 dB penalty to noise levels during the period of 10 p.m. to 7 a.m. to account for people’s increased sensitivity to nighttime noise.

External uses

U.S. National Parks Service monitors noise levels in the Natural Sounds and Night Skies Division of the national parks around the country (Lynch et al. 2011).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Visitor experience: Noise levels are a part of visitor experience to many areas and elevated noise levels in natural areas can interfere with that experience.

Wildlife: Wildlife have been found to avoid areas with prolonged elevated levels of noise.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Buxton et al. 2017)
(Lynch et al. 2011)
(TRPA 2012b)
(TRPA 2012a)

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Single Event Noise

Measure at a glance

Category: Environment
Subcategory: *Noise*

Indicator Overview

Description

This indicator measures the maximum level of noise measured during a discrete activity.

Human and Environmental Drivers

The factors influencing single noise levels vary by the activity generating the noise, but are generally a function of vehicle type and operation patterns. Additional factors that influence the level of noise include wind, temperature, cloud cover, fog, topography, vegetation, and man-made barriers such as homes and other buildings.

Application

In the Basin

TRPA has 15 threshold standards for single event noise (TRPA 2012a);

1) Aircraft Departures/Arrivals between the hours of 8 p.m. and 8 a.m.
2) Aircraft Departures/Arrivals betweeen the hours of 8 a.m and 8 p.m.
3) Watercraft Shoreline Test
4) Watercraft Pass-By Test
5) Watercraft Stationary Test for boats manufactured before January 1, 1993;
6) Watercraft Stationary Test for boats manufactured after January 1, 1993;
7) Motor Vehicles Less Than 6,000 GVW at speeds less than 35 MPH
8) Motor Vehicles Less Than 6,000 GVW at speeds greater than 35 MPH
9) Motor Vehicles Greater Than 6,000 GVW at speeds less than 35 MPH
10) Motor Vehicles Greater Than 6,000 GVW at speeds greater than 35 MPH
11) Motorcycles at speeds less than 35 MPH
12) Motorcycles at speeds greater than 35 MPH
13) Off-Road Vehicles at speeds less than 35 MPH
14) Off-Road Vehicles at speeds greater than 35 MPH
15) Snowmobiles at speeds less than 35 MPH (National Park Service 2017).

External uses

No external uses identified.

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Noise: Noise, by definition, is "unwanted sound," and is a subjective reaction to acoustic energy or sound levels. Excessive noise can impact community ambiance, human health, recreational experience, and wildlife.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(National Park Service 2017)
(TRPA 2012a)

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Water Quality

Miles of Street Sweeping	
Measure at a glance	
Category: Environment ***Subcategory:*** *Water Quality*	
Indicator Overview	
Description	
This indicator" measures the miles of city, county, and state roads that are swept to reduce stormwater pollution during each EIP reporting year as part of regular operations and maintenance procedures.	
Human and Environmental Drivers	
Street sweeping frequency is a balance between need and resources available to support operations	
Application	
In the Basin	
TRPA currently uses "Miles of Street Sweeping" as an EIP performance measure (TRPA 2016).	
External uses	
No external uses identified.	
Literature or Guidance Documents	
No literature or guidance documents identified.	
Relationship with Goal	
Water quality: Street sweeping reduces the pollutant load on streets and prevents pollutants from reaching the lake. Miles of street swept is a measure of input in an activity that reduces pollutant load. The effectiveness of that activity in reducing pollutant load varies by road condition, environmental conditions, and sweeper type and speed.	
Variations of the Measure / Alternatives to the measures	
No variations identified.	
References	
(TRPA 2016)	

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Miles of Roads Decommissioned or Retrofitted

Measure at a glance

Category: Environment
Subcategory: *Water Quality*

Indicator Overview

Description

This indicator measures the length of city, county, state, and federal roads that are retrofittedto reduce stormwater pollution through capital improvements or decommissioned

Human and Environmental Drivers

The amount of city, county, state, and federal roads that are retrofitted or removed is driven by available resources for project implementation.

Application

In the Basin

TRPA uses the "Miles of Roadway Decommissioned or Retrofitted" indicator as an EIP performance measure. EIP performance measures are reported in three categories of treatment priority based on water quality risk.

1) Treated: Roads are considered treated when they have been decommissioned or retrofitted to reduce stormwater runoff and/or pollution.

2) Decommissioned: Roads are decommissioned when they are removed (obliterated) from use permanently and restored. Retrofitted (paved road): A section of paved road is considered retrofitted to reduce stormwater runoff and pollution if all of its runoff infiltrates, or if drainage conveyance and treatment facilities or source controls are installed to collect and treat its runoff and are maintained such that they are functioning as designed.

3) Retrofitted (unpaved road): A mile of unpaved road is considered retrofitted if BMPs have been designed and implemented to disconnect road runoff and prevent sediment transport to water bodies; if stream crossings can pass the 100-year storm; and if the hydraulic length of individual road segments has been shortened to increase road surface sustainability. BMPs should not require maintenance more frequently than every two years, except in the case of damage caused by extreme storm events.

External uses

The US Forest Service measures Road Decommissioning as part of watershed restoration programs (Napper 2017).

Literature or Guidance Documents

No literature of guidance documents identified.

Relationship with Goal

Water Quality: "Miles of Roadway Decommissioned" is a measure of activity that contributes to reducing stormwater pollution loads to improve the clarity of Lake Tahoe. The water quality benefit of decommissioning a given mile or road is dependent on the road location, hydrologic connectivity, and the road's operation and maintenance prior to decommissioning.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Napper 2017)

(Tahoe Regional Planning Agency 2014)

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Road Rapid Assessment Methodology (Road RAM)

Measure at a Glance

Category: Environment
Subcategory: *Water Quality*

Indicator Overview

Description

"Road RAM" measures the road surface condition and maintenance urgency based on the expected downslope water quality caused by runoff. Roadway segments are given a "Road RAM" score which measures the amount of sediment on the road (and thus expected water quality, should the load be washed off) on a scale from 1 (worst) to 5 (best). Road RAM scores are directly measured through empirical observation taken at the time of inspection.

Human and Environmental Drivers

Human: The use of road abrasives during winter increases sediment load and decreases "Road RAM" scores; erosion of nearby native soils due to human/car disturbance increases sediment concentration and decreases "Road RAM" scores; pulverization of road materials (e.g. ice melt salt) by cars increases sediment concentration and decreases "Road RAM" scores; road sweeping removes sediment concentration and increases "Road RAM" scores; Snow haul/ storage using a snow blower and loader to move snow from roadways to a storage facility reduces sediment concentration and increases "Road RAM" scores; air currents caused by traffic move sediment concentration off of roadways which reduces sediment concentration and increases "Road RAM" scores.

Environmental: Erosion of nearby native soils due to wind transport increases sediment concentration and decreases "Road RAM" scores; degradation of tires and road surfaces increases sediment concentration and decreases "Road RAM" scores. Wind and rain storms can clear pollutants off roadways and increase "Road RAM" scores

Application

In the Basin

The "Road RAM" measure is used by the Total Maximum Daily Load (TMDL) to measure sediment concentration on roadways and award credits for sediment reductions in the Tahoe Basin. (California Tahoe Conservancy & Nevada Department of Environmental Protection 2010).

External uses

No external uses identified.

Literature or Guidance Documents

No literature or guidance documents identified

Relationship with Goal

Water Quality: Road RAM is a direct measure of pollutant load on roads and the effectiveness of pollutant load reduction activities (street sweeping, operations and m*aintenance*). Reducing the load of pollutants reaching the lake is essential to attaining the Region's clarity goal and improving water quality in the Tahoe Basin.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(California Tahoe Conservancy & Nevada Department of Environmental Protection 2010)

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Best Management Practices Rapid Assessment Methodology (BMP-RAM)	
Measure at a Glance	
Category: Environment ***Subcategory:*** *Water Quality*	

Indicator Overview
Description
"BMP-RAM" is a field observation methodology to assess the relative condition of urban stormwater treatment infrastructure. Treatment BMPs are given a "BMP-RAM" score based on their relative treatment capacity. Scores range from 1 (lowest capacity and in need of maintenance) to 5 (highly functioning).
Human and Environmental Drivers
Environmental: "BMP-RAM" scores are directly correlated with regular maintenance of stormwater infrastructure. Without maintenance, the capacity of structural BMPs to remove pollutants typically decreases over time *(2NDNATURE LLC & NCE 2017)*. Maintenance restores treatment capability. The relative ability of a structure is directly measured by BMP-RAM. Higher BMP-RAM scores are positively correlated with greater reductions in downstream pollutant load *(2NDNATURE LLC & NCE 2017)*.
Application
In the Basin
The "BMP-RAM" measure is used by the Total Maximum Daily Load (TMDL) to measure sediment concentration on Treatment BMPs and award credits for sediment reductions in the Tahoe Basin. (California Tahoe Conservancy & Nevada Department of Environmental Protection 2010). BMP-RAM scores are also used to establish maintenance frequency. Lower BMP-RAM scores indicate where maintenance is required to ensure the water quality benefits of the BMP is maintained over time.
External uses
No external uses identified.
Literature or Guidance Documents
No literature or guidance documents identified.
Relationship with Goal
Water Quality: This measure identifies the ability of structural BMPs to remove pollutants, which enables better estimation of pollutant loads reaching the lake.
Variations of the Measure / Alternatives to the measures
No variations identified.
References
(2ndNature & NHC 2011) (2NDNATURE LLC & NCE 2015) (California Tahoe Conservancy & Nevada Department of Environmental Protection 2010) (United States Army Corps of Engineers, Sacramento District 2009)

DRAFT

2NDNATURE LLC, NCE. 2015. Road Operation and Maintenance Practices Effectiveness Testing.

2NDNATURE LLC, NCE. 2017. Best Management Practices Rapid Assessment Methodology (BMP RAM) User Guidance Documentv 3.2. 2NDNATURE LLC, Santa Cruz, CA.

2ndNature, NHC. 2011. Synthesis of Existing Information on Stormwater Infiltration BMPs. Santa Cruz, CA.

Ahn K, Rakha H, Trani A, Van Aerde M. 2002. Estimating Vehicle Fuel Consumption and Emissions based on Instantaneous Speed and Acceleration Levels. Journal of Transportation Engineering **128**:182–190.

Ahouissoussi NBC, Wetzstein ME. 1998. A comparative cost analysis of biodiesel, compressed natural gas, methanol, and diesel for transit bus systems. Resource and Energy Economics **20**:1–15.

Alameda-Contra Costa Transit District. 2017. The HyRoad. Available from http://www.actransit.org/environment/the-hyroad/.

Brownstone D. 2008. Key Relationships Between the Built Environment and VMT. Paper prepared for the Committee on the Re lationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption Transportation Research Board and the Divi sion on Engineering and Physical Sciences. University of California, Irvine, Irvine, CA.

Buxton RT, McKenna MF, Mennitt D, Fristrup K, Crooks K, Angeloni L, Wittemyer G. 2017. Noise pollution is pervasive in U.S. protected areas. Science **356**:531–533.

California Tahoe Conservancy, Nevada Department of Environmental Protection. 2010. Road Rapid Assessment Methodology. Available from http://www.tahoeroadram.com/2ndnew_roadram/DownloadFolder/Road_RAM_Technical_Document_FINAL.pdf.

Chen, L.-W. Antony, Malamakal, Tom, Wang, Xiaoliang, Green, Mark, Chow, Judith, Watson, John G. 2014. Evaluation of Prescribed Burning Emissions and Impacts on Air Quality in the Lake Tahoe Basin. This research was supported through an agreement with the USDA Forest Service Pacific Southwest Research Station, using funds provided by the Bureau of Land Management through the sale of public lands as authorized by the Southern Nevada Public Land Management Act. Desert Research Institute.

Chen L-WA, Watson, John G., Wang, Xiaoliang. 2011. Visibility monitoring and standards for the Lake Tahoe Basin: assessment of current and alternative approaches. Prepared for USDA Forest Service. Desert Research Institute, Reno, NV.

CTC. 2012. Development of a Regional Greenhouse Gas Emissions Inventory for the Lake Tahoe Basin. Prepared for California Tahoe Conservancy STI-911006-5371-DFR. Sonoma Technology, Inc., Petaluma, CA.

CTC. 2016. Trout Creek restoration.

Dixon KK, Wolf KL. 2007, May 7. Benefits and Risks of Urban Roadside Landscape: Finding a Livable, Balanced Response. Available from https://nacto.org/docs/usdg/benefits_and_risks_of_an_urban_roadside_landscape_dixon.pdf.

Duranton G, Turner MA. 2011. The Fundamental Law of Road Congestion: Evidence from US Cities. American Economic Review **101**:2616–2652.

Ecola L, Wachs M. 2012. Exploring the Relationship between Travel Demand and Economic Growth. The RAND Corporation, Prepared for: Federal Highway Administration.

EPA. 2011a. Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions. Available from https://www.epa.gov/sites/production/files/documents/memo_nitrogen_framework.pdf.

DRAFT

EPA. 2011b. Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions. Available from https://www.epa.gov/sites/production/files/documents/memo_nitrogen_framework.pdf.

EPA. 2016a. Health and Environmental Effects of Particulate Matter (PM). Available from https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm (accessed June 23, 2017).

EPA. 2016b. Health and Environmental Effects of Particulate Matter (PM). Available from https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm (accessed June 23, 2017).

EPA. 2017a. History of Reducing Air Pollution from Transportation in the United States (U.S.). EPA. Available from https://www.epa.gov/air-pollution-transportation/accomplishments-and-success-air-pollution-transportation (accessed March 22, 2017).

EPA. 2017b. Nitrogen Dioxide (NO2) Pollution. Available from https://www.epa.gov/no2-pollution (accessed June 28, 2017).

Eudy L, Chandler K, Gikakis C. 2010. Fuel Cell Buses in U.S. Transit Fleets: Current Status 2010. Technical Report 560–4979. National Renewable Energy Laboratory. Available from http://www.actransit.org/wp-content/uploads/NREL_rept_OCT2010.pdf.

FHWA. 2017. FHWA Forecasts of Vehicle Miles Traveled (VMT): Spring 2017. Office of Highway Policy Information Federal Highway Administration. Available from https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.pdf.

Frey HC, Rouphail NM, Zhai H, Farias TL, Gonçalves GA. 2007. Comparing real-world fuel consumption for diesel- and hydrogen-fueled transit buses and implication for emissions. Transportation Research Part D: Transport and Environment **12**:281–291.

Green, Mark, DuBois, David, Molenare, John. 2011. Lake Tahoe Visibility Impairment Source Apportionment Analysis. This research was supported by an agreement with the USDA Forest Service Pacific Southwest Research Station, using funding provided by the Bureau of Land Management through the sale of public lands as authorized by the Southern Nevada Public Land Management Act (SNLPMA).

Handy S. 2015. Increasing Highway Capacity Unlikely to Relieve Traffic Congestion. National Center for Sustianable Transportation, University of California, Davis - Department of Environmental Science and Policy.

IPCC, editor. 2015. Climate change 2014: synthesis report. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Lahontan & NDEP. 2010a. Lake Tahoe Total Maximum Daily Load Technical Report. California Regional Water Quality Control Board, Lahontan Region & Nevada Division of Environmental Protection, South Lake Tahoe, California & Carson City, Nevada.

Lahontan & NDEP. 2010b. Final Lake Tahoe Total Maximum Daily Load Report. California Regional Water Quality Control Board, Lahontan Region & Nevada Division of Environmental Protection, South Lake Tahoe, California & Carson City, Nevada.

Lynch E, Joyce D, Fristrup K. 2011. An assessment of noise audibility and sound levels in U.S. National Parks. Landscape Ecology **26**:1297–1309.

Napper C. 2017. Road Decommisioning. Technology and Development Program. USFS. Available from https://www.fs.fed.us/t-d/programs/im/road_decomission/road_decommissioning.shtml (accessed July 14, 2017).

National Park Service. 2017. National Park Service Objectives and Performance Measures. Available from https://www.nps.gov/transportation/transportation_performance_measures.html.

New York City Parks Department. (n.d.). New York City Street Tree Map. Available from https://tree-map.nycgovparks.org/.

DRAFT

Nowak DJ, Heisler GM. 2010. Air Quality Effects of Urban Trees and Parks. National Recreation and Parks Association. Available from http://www.nrpa.org/uploadedFiles/nrpa.org/Publications_and_Research/Research/Papers/Nowak-Heisler-Research-Paper.pdf.

Nowak DJ, Hirabayashi S, Bodine A, Greenfield E. 2014. Tree and forest effects on air quality and human health in the United States. Environmental Pollution **193**:119–129.

OPR. 2013. Preliminary Evaluation of Alternative Methods of Transportation Analysis. Governor's Office of Planning and Research, Sacramento, California. Available from https://www.opr.ca.gov/docs/PreliminaryEvaluationTransportationMetrics.pdf.

PFSC. 2017. Vehicle Miles Traveled Per Capita. Partnership for Sustainable Communities, an interagency partnership of the U.S. Department of Housing and Urban Development (HUD), U.S. Department of Transportation (DOT), and the U.S. Environmental Protection Agency (EPA, Washington, DC. Available from https://www.sustainablecommunities.gov/vehicle-miles-traveled-capita (accessed June 1, 2017).

SACOG. 2013. Congested Vehicle Miles Traveled per Capita, An Important Indicator for Traveler Satisfaction and Transportation Cost-Effectiveness. Sacramento Area Council of Governments. Available from https://collaboration.fhwa.dot.gov/dot/fhwa/pmc/Documents/AMPO%20Listening%20Session/SACOG%20Presentations.pdf.

SACOG. 2016a. Metropolitan Transportation Plan/Sustainable Communities Strategy. Sacramento Area Council of Governments, Sacramento. Available from http://www.sacog.org/sites/main/files/file-attachments/chapter_5b_vehicle_miles_traveled_and_roadway_congestion_trends_and_performance.pdf.

SACOG. 2016b. Metropolitan Transportation Plan/ Sustainable Communities Strategy. Sacramento Area Council of Governments. Available from http://www.sacog.org/sites/main/files/file-attachments/mtpscs_complete.pdf.

San Francisco Planning Department. 2014, Fall. San Francisco Urban Forest Plan. Available from http://default.sfplanning.org/plans-and-programs/planning-for-the-city/urban-forest-plan/Urban_Forest_Plan_Final-092314WEB.pdf.

Schwarz K et al. 2015. Trees Grow on Money: Urban Tree Canopy Cover and Environmental Justice. PLOS ONE **10**:e0122051.

Seattle Department of Transportation. 2015, February. Trees and Sidewalks Operations Plan. Available from https://www.seattle.gov/transportation/docs/TreeSidewalksOperationsPlan_final215.pdf.

Smit R, Brown AL, Chan YC. 2008. Do air pollution emissions and fuel consumption models for roadways include the effects of congestion in the roadway traffic flow? Environmental Modelling & Software **23**:1262–1270.

Tahoe Regional Planning Agency. 2014. Transportation Monitoring Report 2014. Available from file:///F:\Transportation\Data\Monitoring\1%20Regional%20Monitoring%20Reports\Monitoring%20Report%202016\Draft%20Report\2014%20Monitoring%20Report_final.docx.

Tahoe Regional Planning Agency. 2017. Transportation Project List. Available from https://eip.laketahoeinfo.org/Project/TransportationList.

TRPA. 1982. Study Report for the Establishment of Environmental Threshold Carrying Capacities. Tahoe Regional Planning Agency, Stateline, NV.

TRPA. 2012a. Resolution No. 82-11. Tahoe Regional Planning Agency, Stateline, NV.

TRPA. 2012b. Regional Plan. Tahoe Regional Planning Agency, Stateline, NV.

TRPA. 2016, January 21. Lake Tahoe Environmental Improvement Program Project Tracker. Available from https://eip.laketahoeinfo.org/.

DRAFT

UCLA. 2009. Measuring greenhouse gas emissions for SB375 implementation. UCLA Lewis Center for Regional Policy Studies, Los Angeles. Available from https://www.arb.ca.gov/cc/sb375/rtac/meetings/070709/commentaddendum.pdf.

United States Army Corps of Engineers, Sacramento District. 2009. Best Management Practices Maintenance Rapid Assessment Methodology. Available from http://tahoeroadram.com/bmpramshow/DownloadFolder/BMP%20RAM%20Technical%20Document.pdf.

United States Energy Information Administration. 2016. International Energy Outlook 2016: Transportation sector energy consumption.

USDA Forest Service. 2002. The Effects of Urban Trees on Air Quality. Available from https://www.nrs.fs.fed.us/units/urban/local-resources/downloads/Tree_Air_Qual.pdf.

Zhu D, Kuhns HD, Brown S, Gillies JA, Etyemezian V, Gertler AW. 2009. Fugitive Dust Emissions from Paved Road Travel in the Lake Tahoe Basin. Journal of the Air & Waste Management Association **59**:1219–1229.

DRAFT