Interagency Transportation, Land Use, and Climate Change Initiative

Central New Mexico Climate Change Scenario Planning Project

Ben Rasmussen (Volpe) and Aaron Sussman (MRCOG)
August 12, 2015
Purpose/History

Purpose
- Focus: 50% adaptation and 50% mitigation
- Uses scenario planning as a framework
- Integrates into LRTP
- Involves multiple agencies with different priorities; not just transportation

Two locations
- Coast: pilot project on Cape Cod, Massachusetts (2010-11)
- Non-coastal: Central New Mexico (2013-15)

Key differences
- Additional modeling software v. existing modeling software
- State of the practice
Partnerships

- Federal funding sponsors
  - U.S. Department of Transportation
  - Federal Highway Administration
  - U.S. Department of the Interior
  - Bureau of Reclamation
  - National Park Service
  - U.S. Fish & Wildlife Service

- Supporting federal agencies
  - FEMA
  - Sandia National Laboratories
  - NRCS
  - U.S. Forest Service

- Regional and local agencies / governments
  - Mid-Region Metropolitan Planning Organization
  - Albuquerque Bernalillo County Water Utility Authority

- Private and academic entities
  - Ecosystem Management, Inc.
  - The University of New Mexico
Central New Mexico
Climate Change Adaptation Process

- Identify:
  - Regional climate change impacts
  - The effect of these impacts on transportation, land use, and natural resources
  - The effect of transportation and land use policy choices on climate change impacts

- Example adaptation strategies:
  - Mixed use/density
  - Buffers

*How will these strategies be affected by climate change impacts?*
*How will these strategies improve or reduce resiliency?*
# Climate Change Mitigation Process

- **Estimate** (for each development scenario):
  - Vehicle miles traveled
  - GHG emissions

- **Example mitigation strategies**:
  - Mixed use/density
  - Alternative fuels
  - Transit
  - Nonmotorized investments

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<th>Analysis Capability</th>
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<td>Q</td>
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*Explanation of abbreviations:
- **L:** Low term
- **M:** Medium term
- **S:** Short term
- **U:** UrbanSim
- **C:** CUBE
- **Q:** Qualitative
- **P:** Post Process
- **O:** Off Model
Research Context

- FHWA Adaptation Framework & Climate Resilience Pilots
- FHWA Scenario Planning Guidebook & Peer Exchanges
- Cape Cod Pilot Project Guidebook
- NPS Climate Change Scenario Planning Handbook
- BoR Climate Change Report
- Volpe Climate Futures Tool
- Studies on GHG Emission Reduction Strategies
Research Context

- Research on Climate Change Mitigation
- Research on Climate Change Adaptation
- Research on Scenario Planning

This Project
Successful Methodologies

- Integrated land use and travel demand models
- Off-model GHG analysis
- Analysis of the effect of different land use patterns on water consumption using data from the local water utility
- Integrated climate analysis into the transportation plan
- Leveraged partnerships and existing studies
Recommendations for Future Research

- Plan for climate change beyond traditional planning time frames
- Conduct early exploratory analysis well before formal plans need to be developed
- Develop a complete picture of climate change impacts specific to the region before developing conceptual land use and transportation scenarios
Integrating Climate Change Analysis into the Metropolitan Transportation Planning Process

Aaron Sussman, AICP
Senior Planner

Mid-Region Council of Governments
Albuquerque and Central NM

- Albuquerque population = 555,000
  - Less than 100,000 in 1950
  - Metropolitan area = 900,000
    (Projected >1.3 million by 2040)

- City area = 190 mi.$^2$ / MSA = 8,400 mi.$^2$

- Surrounded by mountains to the east; tribal lands to north, south, and west

- Northern edge of Chihuahuan Desert

- 9” of rain per year

- Elevation = 5312’
Central New Mexico Climate Change Scenario Planning Project

- Partnerships with range of federal agencies, US DOT Volpe Center
- Understanding of climate trends
  - Temperature & precipitation levels
- Climate change impacts on central NM
  - Droughts
  - Wildfires
  - Flooding
  - Water availability
- Consider whether development patterns make us more or less resilient to climate impacts
Integration with Futures 2040 Metropolitan Transportation Plan

- MTP adopted April 17, 2015
- Expanded scenario planning
- Climate change as way to frame discussions on future growth
- MTP performance measures
  - Transportation conditions
  - Air quality / emissions
  - Water consumption
  - Development locations
Addressing Climate Change through Regional Planning Efforts

Mitigation

Can we grow and invest in ways that reduce GHG emissions?
- Targeted density
- Mixed-use development
- Public transit
- Roadway efficiency improvements

Adaptation

Will our development choices make us more or less resilient to the impacts of climate change?
- Minimizing growth in vulnerable areas
- Water availability and consumption
Changing Climate Conditions


- Average temperature increased by 0.7°F per decade
- Twice the global average

Source: NOAA
Upper Rio Grande Impact Assessment

- Study completed December 2013
  - Bureau of Reclamation
  - Army Corps of Engineers
  - Sandia National Labs
- Evaluated of climate, hydrology, and water operations of the upper Rio Grande basin of Colorado and New Mexico
- Water availability projections
- Starting point for assessing climate impacts
All 112 scenarios result in higher temperatures (methodology replicated in tool developed by Volpe Center)

Precipitation is highly variable, which may lead to more intense droughts and more extreme events

Earlier snowmelt runoff → changes in timing of river flows, affects water availability
Water Availability in 2100

According to the Upper Rio Grande Impact Assessment:

- Rio Grande flows decrease by \( \frac{1}{3} \)
- San Juan-Chama flows decrease by \( \frac{1}{4} \)
- Significant impacts to water supplies for Albuquerque area
Water Availability in ABQ Area: 2040

River Flows in 2040 Compared to Historic Data (by GCM grouping)

- Rio Grande
- San Juan-Chama system

Change Compared to Historic

<table>
<thead>
<tr>
<th>GCM Grouping</th>
<th>Warm-Dry</th>
<th>Warm-Wet</th>
<th>Hot-Dry</th>
<th>Hot-Wet</th>
<th>Central</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>-14%</td>
<td>10%</td>
<td>-20%</td>
<td>-5%</td>
<td>-7%</td>
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<tr>
<td></td>
<td>-6%</td>
<td>0%</td>
<td>-14%</td>
<td>-3%</td>
<td>-3%</td>
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</table>
2040 Regional Forecast

- 460,000 new people
- 185,000 new jobs
Trend Scenario:
Population and Employment 2040

Population Growth Trend Scenario 2012 to 2040
- No Growth
- 1 to 1500
- 1501 to 2500
- 2501 to 5000
- 5001 to 10000
- 10001 to 21762

The AMPA is projected to grow by 438,500 people, or 50% over the next 28 years. Approximately 71% will take place in Bernalillo County, while Sandoval County will capture 17% and Valencia County will capture 11%.

Overall population growth is expected throughout the region and is more pronounced in larger zones. While Albuquerque’s core (defined here as the 1990’s boundary) captures 17% of all new growth, population growth will also be accommodated by several planned subdivisions throughout the region.

Employment Growth Trend Scenario 2012 to 2040
- No Growth
- 1 to 500
- 501 to 1000
- 1001 to 2500
- 2501 to 4349

The AMPA is projected to grow by 182,000 jobs by 2040. Bernalillo County is expected to capture 72% percent of growth, followed by Sandoval County with 22% percent and Valencia County with 5.4 percent.

Employment growth will continue to concentrate throughout existing employment centers while new nodes of economic activity are also expected throughout the region.
Principles of the Preferred Scenario

- Link land use and transportation decision-making
- Concentrated development in activity centers and transit nodes
- Mix of uses in activity centers to promote alternative modes and shorten trip lengths
- Greater range of housing and transportation choices, including transit service expansion
- Maximize utility of existing infrastructure
Preferred Scenario Components

- Increase attractiveness:
  - Activity Centers
  - Transit Nodes

- Infrastructure differences:
  - Same roadway network
  - Built-out transit network

- Same levels of population and employment growth as the Trend Scenario
Scenario Planning
Modeling Process

- UrbanSim – market-based land use forecasting tool
- Cube – four-step travel demand model
- Integrated models with feedback loop
  - 2012 base year, 2025 iteration, 2040 forecast
Scenario Planning Modeling Process

- **Carrots rather than sticks approach to future development**
  - Apply “shifters” to incentivize development in certain locations
  - Growth was not forced or allocated manually

- **Key question:** Does emphasizing growth in activity centers and near transit reduce development in at-risk locations?

- Evaluate distribution of growth and resulting transportation conditions
Volume: Trend vs. Preferred

Congestion: 2040 Preferred

Difference in Daily Traffic Volume, 2040 Trend - 2040 Preferred

- Trend +++
- Trend ++
- Trend +
- Preferred +
- Preferred ++
- Preferred +++
Differences: Trend vs. Preferred

- Average speeds $\uparrow$ 15%
- Commute time $\downarrow$ 18%
- Hours traveled $\downarrow$ 17%
- Miles traveled $\downarrow$ 4%
Development Footprint

- 5% reduction in overall number of acres consumed in 2040 in the Preferred Scenario compared to the Trend Scenario
- 12,600 fewer acres of residential development
Climate Change-Related Evaluation Measures

- Wildland-Urban Interface (wildfire risk area)
- FEMA-designated 100-year floodplains
- Crucial Habitat Assessment Tool
- Water consumption
- CO₂ emissions
Wildland-Urban Interface

Housing + Employment Growth – Intermix Area Only

- Trend: 84%
- Preferred: 63%

Mid-Region Council of Governments
100-Year Floodplains

What we hoped to do:

- Quantify potential increase in flood risks
- Identify areas that will be at risk as climate conditions change
- Measure current and future development on new high-risk areas
100-Year Floodplains

What we ended up doing:

- Case study: potential changes to 100-year 24-hour design storm on Calabacillas Arroyo
  - 10% increase in precip. → 25% increase in flow
  - 25% increase in precip. → 75% increase in flow
High Flood Risk Area

What we ended up doing:

- Measure current and future development on existing flood plains only
- Reduce zoning capacity in floodplains by 20% (minimal impact)
Crucial Habitat Areas

- Western Governors Association tool – ranking for 1-mi² hexagons
- Overlay land use with crucial habitat scores
- Challenges:
  - Most critical locations are in the urban core - Lowest risk areas also those subject to potential sprawl
- Not much difference between scenarios
- Conclusion: Better to develop more intensively in areas where development already exists
Water Consumption

- How we grow impacts how much water we consume
- Analyze consumption patterns by land use type and housing mix:
  - Single-family vs multi-family
  - Large-lot vs small-lot
- Daily residential consumption dropping locally and nationally
  - 1994: 250 gallons per capita
  - Today: ~135 gallons per capita

Source: Albuquerque Bernalillo County Water Utility Authority
Water Consumption

- Multi-family housing units consume less water on a per-capita basis
- Correlation between lot size and consumption for single-family homes
- Determine water consumption per acre for different land uses
- 5.5 billion fewer gallons consumed annually for residential purposes in Preferred Scenario

Residential Water Consumption

<table>
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<tr>
<th>Trend</th>
<th>Preferred</th>
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<tr>
<td>45%</td>
<td>36%</td>
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Emissions Reduction Strategies

Preferred Scenario Components:

- Expanded transit service
- Transit-oriented development
- Land use / increased density
  - Zoning
  - Infill
  - Development incentives

- Many other strategies are discussed in the 2040 MTP but could not be included in modeling environment

- Additional analysis conducted by project team
Preferred Scenario:

- Reduction in VMT, VHT, VHD
- Reduction in river crossing trips
- Increase in systemwide speed
- Increase in proximity to jobs, activity centers
- Increase in transit usage

GHG Emissions

Mobile-Source CO₂ Emissions

- Trend: 42%
- Preferred: 30%
Changes in Preferred Scenario Compared to Trend Scenario

<table>
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<tr>
<th>Category</th>
<th>Change</th>
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<tr>
<td>New Land Developed</td>
<td>-5%</td>
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<tr>
<td>Vehicle Miles Traveled</td>
<td>-4%</td>
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<tr>
<td>CO$_2$ Emissions</td>
<td>-8%</td>
</tr>
<tr>
<td>Residential Water Consumption</td>
<td>-6%</td>
</tr>
<tr>
<td>Growth in Flood Risk Areas</td>
<td>-2%</td>
</tr>
<tr>
<td>Growth in Fire Risk Areas</td>
<td>-10%</td>
</tr>
<tr>
<td>Development in Crucial Habitat Areas</td>
<td>-1%</td>
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Lessons Learned

_Tying scenario planning to metropolitan transportation planning process has its pros and cons_

**Pros**

- Structure of MTP (built-in forecasting) ensures scenario planning is linked to policy decisions
- Market-based modeling tools generated realistic scenarios that were immediately respected

**Cons**

- MTP development process is constrained by member agency policies and investment decisions
- Market-based modeling approach not utilized to diagnose necessary changes in region
Lessons Learned / Discussion

- Land use and transportation scenarios lend themselves to creative spatial analysis
- Analysis requires understanding of changing conditions and impacts to natural features (e.g. floodplains, fire risk areas)
- Creating an inventory of vulnerable infrastructure and at-risk locations is a challenging but critical first step
- Few agencies are linking climate change impacts with development policies and transportation decision-making, so the MPO has a role to play
- Should we talk about climate change directly, or co-benefits?
Project Benefits

- Climate change as framing device for scenario planning and a way to introduce new measures
- Connection between transportation, land use, and water
- Create a sense of urgency
- Agency connections
  - Project intended to integrate federal-land management areas into MPO planning
  - New partnerships:
    - Bureau of Reclamation
    - Army Corps of Engineers
    - Water Utility Authority
    - University of New Mexico
    - Sandia National Labs
Downscaled Climate Data Processing Tool

### Variables

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<tbody>
<tr>
<td>Precipitation (mm/day)</td>
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<tr>
<td>Maximum daily temperature (°C)</td>
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<tr>
<td>Minimum daily temperature (°C)</td>
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<tr>
<td>Average daily temperature (°C)—<em>derived by averaging max &amp; min</em></td>
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<tr>
<td>Average daily wind speed</td>
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### Projections Range

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- Downscaled (fine spatial resolution translations) of CMIP3 climate projections
- Based on 112 model runs: 9 models, 3 emissions scenarios
- Supplied by Bureau of Reclamation Technical Services Center
- Updated CMIP5 projections recently became available (July 2014)
Changes in climate means in 2040, by GCM run

- **Future 1**: Warm Wet
- **Future 2**: Hot Wet
- **Future 3**: Central
- **Future 4**: Warm Dry
- **Future 5**: Hot Dry

Change in average annual precipitation (in)

Change in annual average temperature (°F)
MRCOG-Identified Grid Cells of Interest

Original Grid Cell

SW quadrant of Albuquerque (35.0625, -106.6875)
Elevation: 4,940 ft.
Central NM Climate Futures - 2040

**Warm, Wet**
- +2.4 °F in average daily maximum temperature
- +0.55” in average annual precipitation
- 2X more days > 100 °F than the current 5 days
- 2.1X more consecutive days > 100 °F than the current 2 days
- Slight increase in avg. max 24-hr precipitation (7.8%)

**Hot, Wet**
- +4.1 °F in average daily temperature
- +0.15” in average annual precipitation
- 4X more days > 100 °F than the current 5 days
- 3.3X more consecutive days > 100 °F than the current 2 days
- Slight increase in avg. max 24-hr precipitation (5.9%)

**Central**
- +3.5 °F in average daily maximum temperature
- -0.26” in average annual precipitation
- 3.3X more days > 100 °F than the current 5 days
- 3.2X more consecutive days > 100 °F than the current 2 days
- Slight decrease in max 24-hr precipitation (-0.03%)

**Warm, Dry**
- +2.9 °F in average daily maximum temperature
- -0.87” in average annual precipitation
- 2.8X more days > 100 °F than the current 5 days
- 2.6X more consecutive days > 100 °F than the current 2 days
- Slight decrease in avg. max 24-hr precipitation (-5.1%)

**Hot, Dry**
- +4.3 °F in average daily maximum temperature
- -0.74” in average annual precipitation
- 4.3X more days > 100 °F than the current 5 days
- 3.7X more consecutive days > 100 °F than the current 2 days
- Slight decrease in avg. max 24-hr precipitation (-6.5%)
**MRCOG-Identified Grid Cells of Interest**

**Grid Cell #1**
- Rio Rancho area, N of Albuquerque (35.3125, -106.6875)
- Elevation: 5,615 ft.

**Grid Cell #2**
- Los Lunas area, S of Albuquerque (34.6875, -106.6875)
- Elevation: 5,005 ft.

**Grid Cell #3**
- Cibola National Forest, E of Albuquerque (35.0625, -106.3125)
- Elevation: 7,025 ft.

**Grid Cell #4**
- General desert area, SE of Albuquerque (34.5625, -106.0625)
- Elevation: 6,155 ft.

**Grid Cell #5**
- Santa Fe National Forest, N of Albuquerque (35.8125, -106.6875)
- Elevation: 7,435 ft.

**Original Grid Cell**
- SW quadrant of Albuquerque (35.0625, -106.6875)
- Elevation: 4,940 ft.
Total Days Over 100°F in Baseline (1950-1999) and 2040 (2025-2055 average)
Mitigation Component

- Greenhouse Gas Mitigation Strategies
  - Analysis Completed During Scenario Planning Workshop Phase
  - Higher Priority Strategies Evaluated Post-Workshop
  - Strategies to be Discussed in Final Report

- Summary of Work by Department of Civil Engineering at the University of New Mexico
  - Dr. Gregory Rowangould
  - Mohammad Tayarani
  - Amir Poorafakhraei
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Strategies Evaluated in Scenario Planning Workshops Using Models

- **Zoning Changes**
  - Allowable densities/uses

- **Infill Development**
  - Increased probability of development through incentives

- **Transit-Oriented Development**
  - Increased densities through zoning and incentives
  - Mode shift/access through transit access

- **Improving Public Transportation**
  - Mode shift/access through transit access
Other High Priority GHG Mitigation Strategies

- Urban Growth Boundaries
- VMT Tax
- Bicycle Infrastructure
- Incident Management
- Traffic Signal Enhancement
- Roadway Connectivity
Urban Growth Boundary

- Prohibiting future development outside the existing metropolitan area footprint
- Travel demand model analysis/EPA MOVES model
- Comparison to Preferred Scenario:
  - Additional reduction in per capita VMT by 2 percent
  - Additional reduction in GHG emissions by 3.8 percent
VMT Tax

- Increasing the cost of driving by imposing a per-mile charge to driving
- The tax rate matters
  - If VMT tax is set to be equal to today’s fuel tax, it could increase emissions by reducing incentives to drive fuel-efficient vehicles
  - A VMT tax set to be higher than today’s fuel tax reduces driving incentives

<table>
<thead>
<tr>
<th>Additional VMT Tax</th>
<th>Equivalent Gas Tax Increase ($/gallon)</th>
<th>Daily VMT per Capita</th>
<th>CO$_2$-eq (tonne/day)</th>
<th>% Change in CO$_2$-eq</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.00</td>
<td>$0.00</td>
<td>20.0</td>
<td>13,352</td>
<td>0%</td>
</tr>
<tr>
<td>$0.03</td>
<td>$0.62</td>
<td>19.4</td>
<td>12,572</td>
<td>-6%</td>
</tr>
<tr>
<td>$0.06</td>
<td>$1.24</td>
<td>18.5</td>
<td>11,959</td>
<td>-10%</td>
</tr>
<tr>
<td>$0.12</td>
<td>$2.47</td>
<td>17.1</td>
<td>10,968</td>
<td>-18%</td>
</tr>
<tr>
<td>$0.25</td>
<td>$5.15</td>
<td>15.0</td>
<td>9,616</td>
<td>-28%</td>
</tr>
<tr>
<td>$0.50</td>
<td>$10.30</td>
<td>12.3</td>
<td>7,955</td>
<td>-40%</td>
</tr>
</tbody>
</table>
Bicycle Infrastructure

- Travel demand model estimates bike trips based solely on household characteristics and trip distance; it does not factor in presence of bicycle or pedestrian facilities
- Analysis of full build out of City of Albuquerque’s Bicycle Plan
- Comparison to Preferred Scenario:
  - Additional 0.4 percent decrease in VMT and GHG emissions
  - Cost of providing bike lanes and paths is small
Incident Management

- Incident management programs should reduce GHG emissions if they reduce delays and increase speed.
- No studies exist that quantify GHG emissions reduction from incident management programs.

![Graph showing the relationship between average speed (Miles per Hour) and 2040 Carbon Dioxide Emissions (grams/mile).](image-url)
Traffic Signal Enhancement

- Adaptive signal control to optimize signal timing along corridor
  - Bernalillo County installed such a system on Alameda Blvd
  - Traffic data was collected before and after showing reduced morning peak travel time by 21 percent and evening peak travel time by 11 percent and reduction of GHG emissions of 5.9 percent

- Applied a reduction factor to two other congested corridors

<table>
<thead>
<tr>
<th>Road</th>
<th>CO₂-eq (tonnes/day)</th>
<th>% of 2040 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Alameda</td>
<td>60.8</td>
<td>57.2</td>
</tr>
<tr>
<td>Montgomery/Montano</td>
<td>288</td>
<td>276</td>
</tr>
<tr>
<td>Coors</td>
<td>442</td>
<td>426</td>
</tr>
</tbody>
</table>
Roadway Connectivity

- Street grids provide shorter path options for travel than less connected networks with cul-de-sacs and dead ends and provide better bicycle/walk/transit conditions.

- Prior studies indicate a VMT elasticity of -0.12 for both:
  - Intersection density
  - Proportion of four-way intersections

- Four districts of the metropolitan area were evaluated:

<table>
<thead>
<tr>
<th>Neighborhood</th>
<th>Area (km²)</th>
<th>Intersections</th>
<th>Intersection Density</th>
<th>% Change in VMT from SW Albuquerque a</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW Albuquerque</td>
<td>0.78</td>
<td>51</td>
<td>65.6</td>
<td>0.0%</td>
</tr>
<tr>
<td>NW Albuquerque</td>
<td>0.71</td>
<td>50</td>
<td>70.6</td>
<td>-0.9%</td>
</tr>
<tr>
<td>University Area</td>
<td>0.67</td>
<td>56</td>
<td>83.9</td>
<td>-3.3%</td>
</tr>
<tr>
<td>Downtown Albuquerque</td>
<td>0.45</td>
<td>52</td>
<td>116.8</td>
<td>-9.4%</td>
</tr>
</tbody>
</table>
Conclusions from Additional Analysis

- Additional GHG mitigation strategies will result in lower GHG emissions than what was included in the preferred scenario.

<table>
<thead>
<tr>
<th></th>
<th>CO2-eq Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Boundary</td>
<td>512</td>
</tr>
<tr>
<td>VMT Tax 0.005 per mile&lt;sup&gt;a&lt;/sup&gt;</td>
<td>107</td>
</tr>
<tr>
<td>VMT Tax 0.03 per mile</td>
<td>780</td>
</tr>
<tr>
<td>VMT Tax 0.12 per mile</td>
<td>2,384</td>
</tr>
<tr>
<td>Bicycle Infrastructure</td>
<td>49.1</td>
</tr>
<tr>
<td>Traffic Signal Enhancement</td>
<td>27.6</td>
</tr>
</tbody>
</table>
Resources Available

- Final Report/Guidebook
- Technical Report
- Integration Plan
- Reports for BLM and FWS
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