Interagency Transportation, Land Use, and Climate Change Initiative

Central New Mexico Climate Change Scenario Planning Project

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Volpe The National Transportation Systems Center

Advancing transportation innovation for the public good

U.S. Department of Transportation

Office of the Secretary of Transportation

John A. Volpe National Transportation Systems Center

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

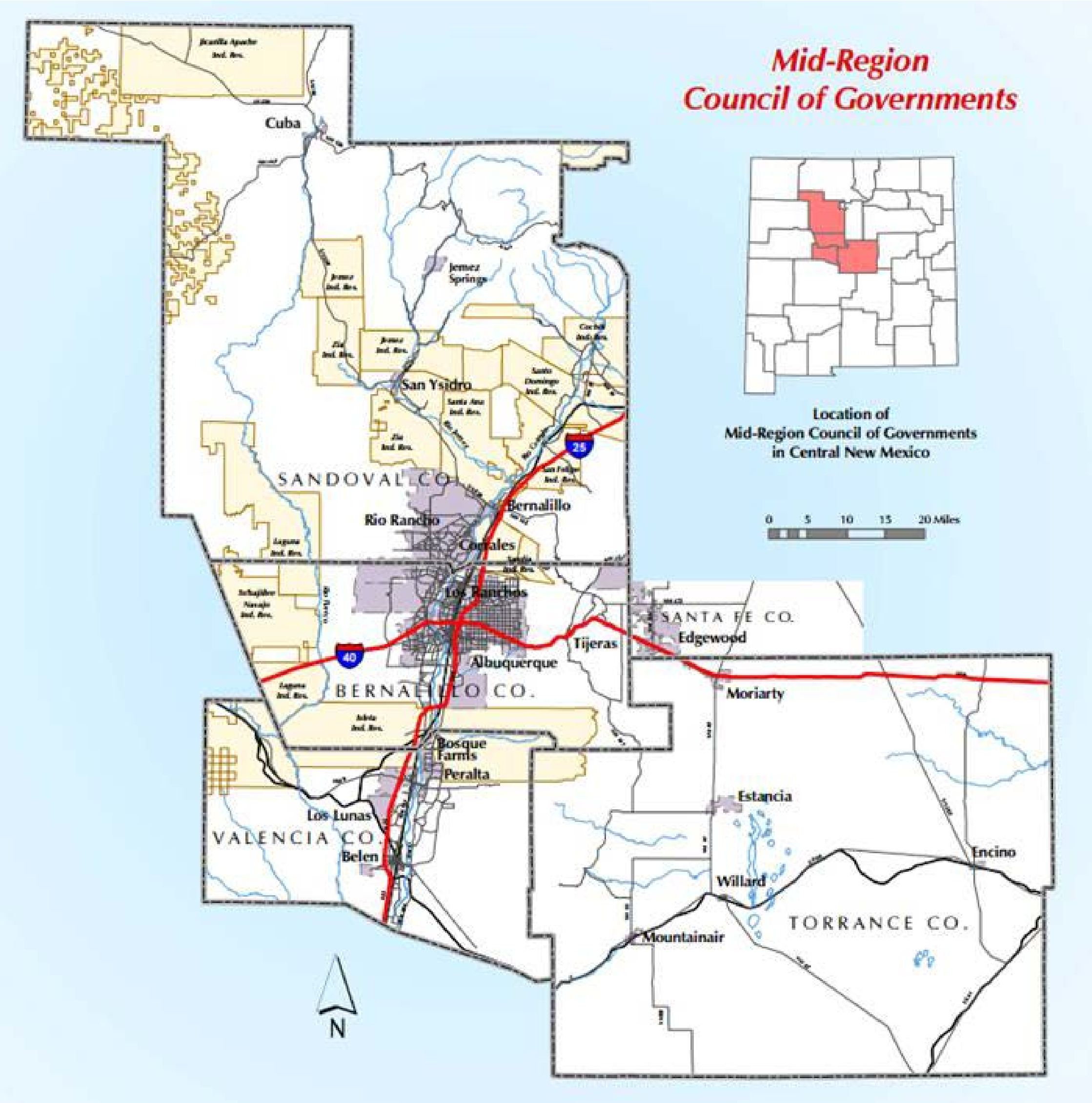
- Two locations
  - Coast: pilot project on Cape Cod, Massachusetts (2010-11)
  - Non-coastal: Central New Mexico (2013-15)

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

Partnerships

- Federal funding sponsors
- Supporting federal agencies
- Regional and local agencies / governments
- Private and academic entities

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

Strategy	GHG Mitigation Potential	Analysis Capability
Zoning changes	●●●●● L	●●●●● U
Infill development	●●●●○ L	●●●●○ U
Transit oriented development	●●●●○ L	●●●●○ U,C
Building design standards	●●○○○ L	●○○○○ Q
Urban growth boundaries	●●●●● M	●●●●● U
Bicycle and pedestrian infrastructure improvements	●●●○○ S	●●○○○ O,P,Q
Improving public transportation	●●●○○ S	●●●○○ C
Establishing a complete streets policy	●●○○○ L	●○○○○ Q
Road pricing (HOT lanes/congestion charging)	●●●○○ S	●●○○○ C,P
HOV facilities	●○○○○ M	●○○○○ Q,P
Parking management	●●●○○ S	●●●○○ C
Car sharing	●○○○○ S	●○○○○ Q
Bike sharing	●○○○○ S	●○○○○ Q
Ride sharing	●○○○○ S	●●●○○ Q,C
Travel demand management-educational	●○○○○ S	●○○○○ Q
Travel demand management-transit incentives	●●●○○ S	●●○○○ Q,P
"Wheels" tax (VMT charging)	●●●●● S	●●●●○ C
Traffic signal enhancement	●●●○○ S	●●●○○ C,P
Incident management	●●○○○ S	●○○○○ Q
Intersection improvement	●○○○○ S	●●●●○ P,C
Establishing roadway connectivity standards	●●●○○ L	●●●●○ C
Electric vehicle infrastructure support	●●○○○ M	●○○○○ Q,M
Heavy-duty vehicle retrofit	●○○○○ M	●●●●○ Q,M
Truck-stop electrification technologies	●○○○○ S	●●○○○ M
Construction activities	●○○○○ M	●○○○○*
Reduce emissions associated with electricity generation from fossil fuel	●●●●● M	●○○○○**

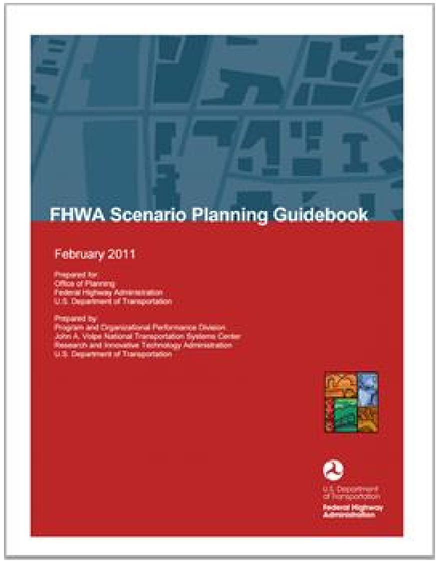
●○○○○ Low → ●●●●● High

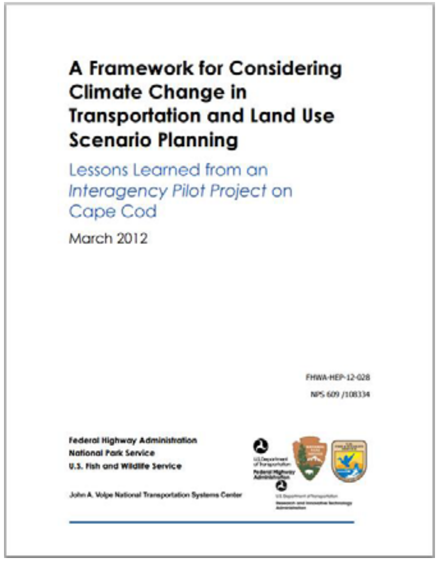
L = long term
M = medium term
S = short term

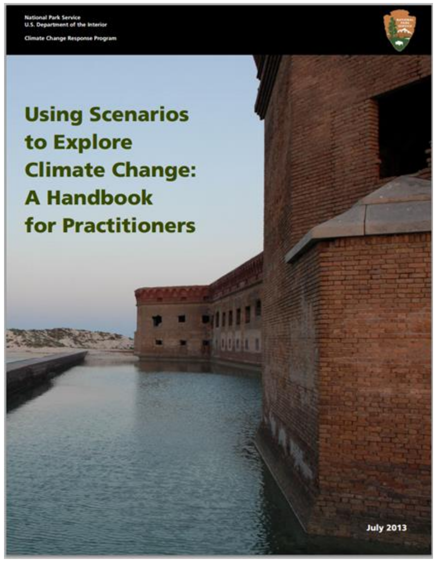
U = UrbanSim, C = CUBE,
M = MOVES, O = Off Model,
P = Post Process, Q = Qualitative

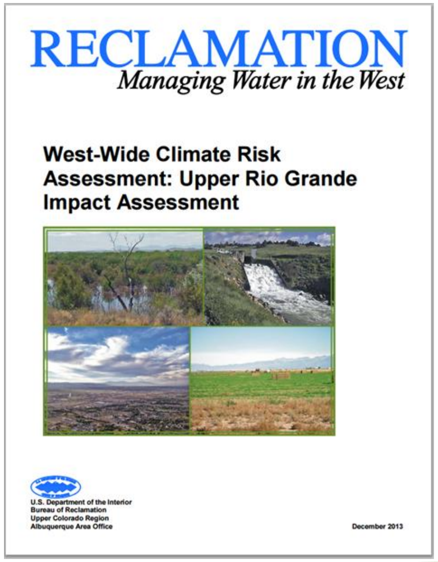
Research Context

- ❑ 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

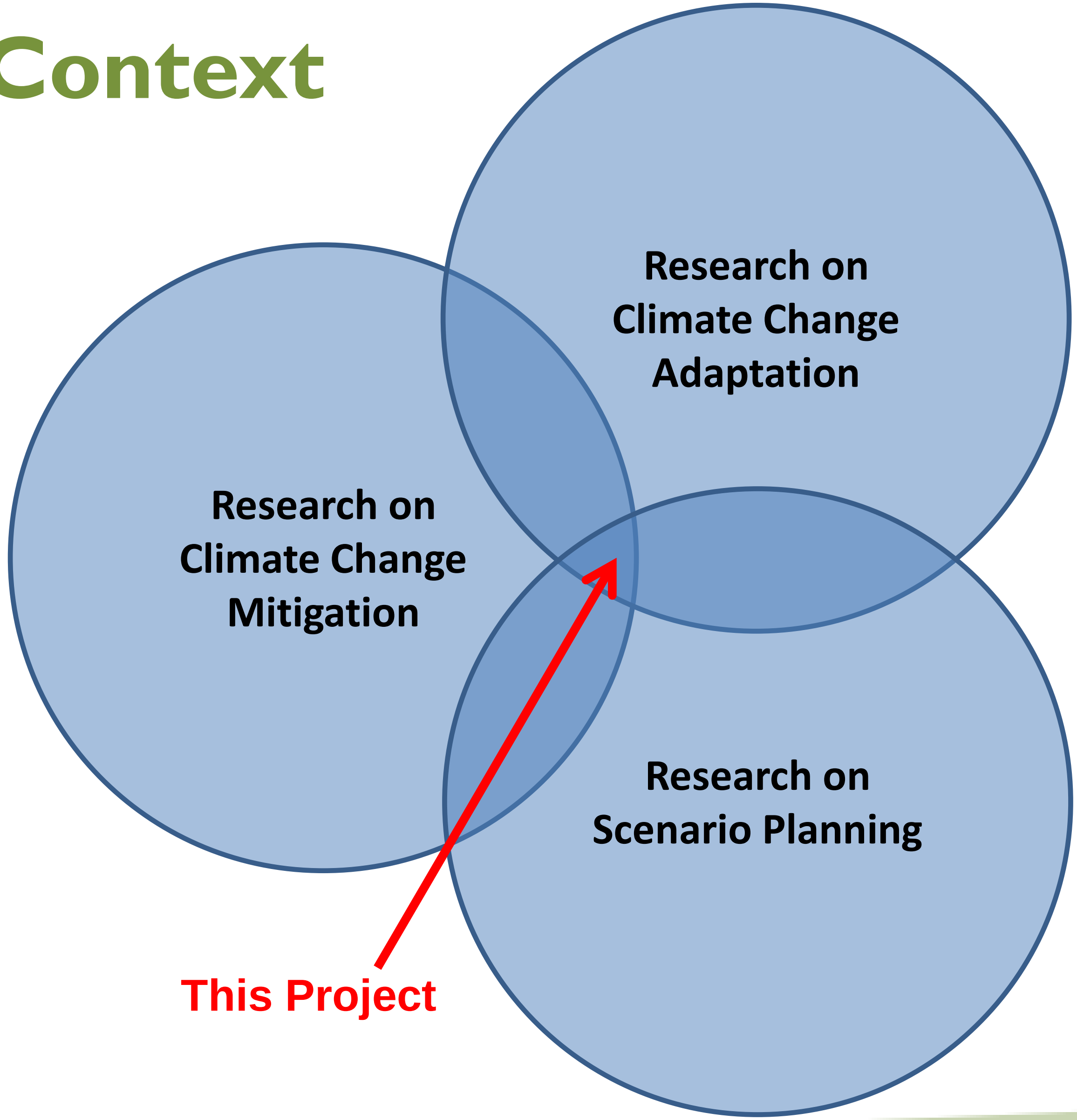








Research Context



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

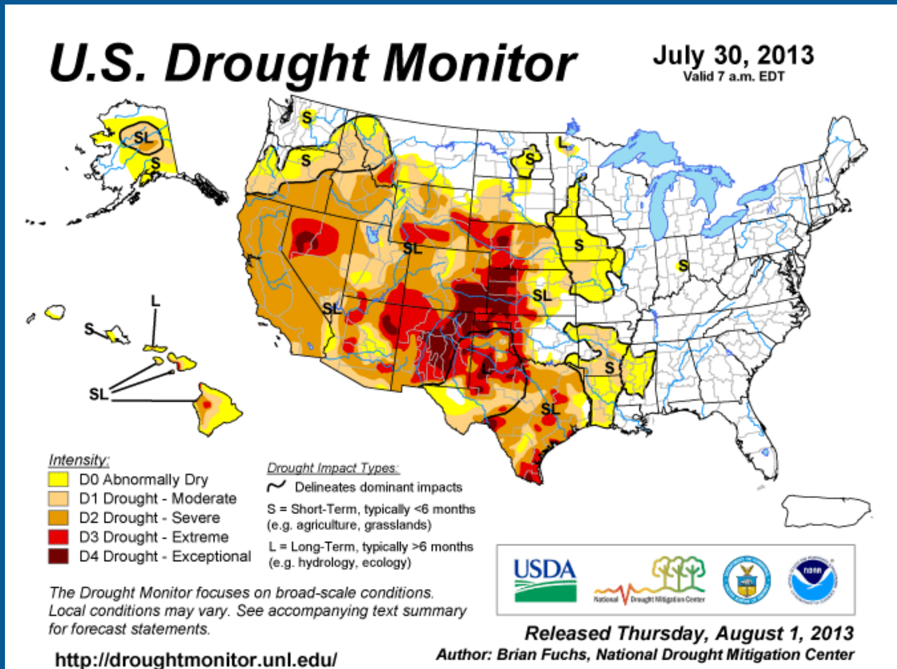
Integrating Climate Change Analysis into the Metropolitan Transportation Planning Process

Aaron Sussman, AICP
Senior Planner

Mid-Region Council of Governments

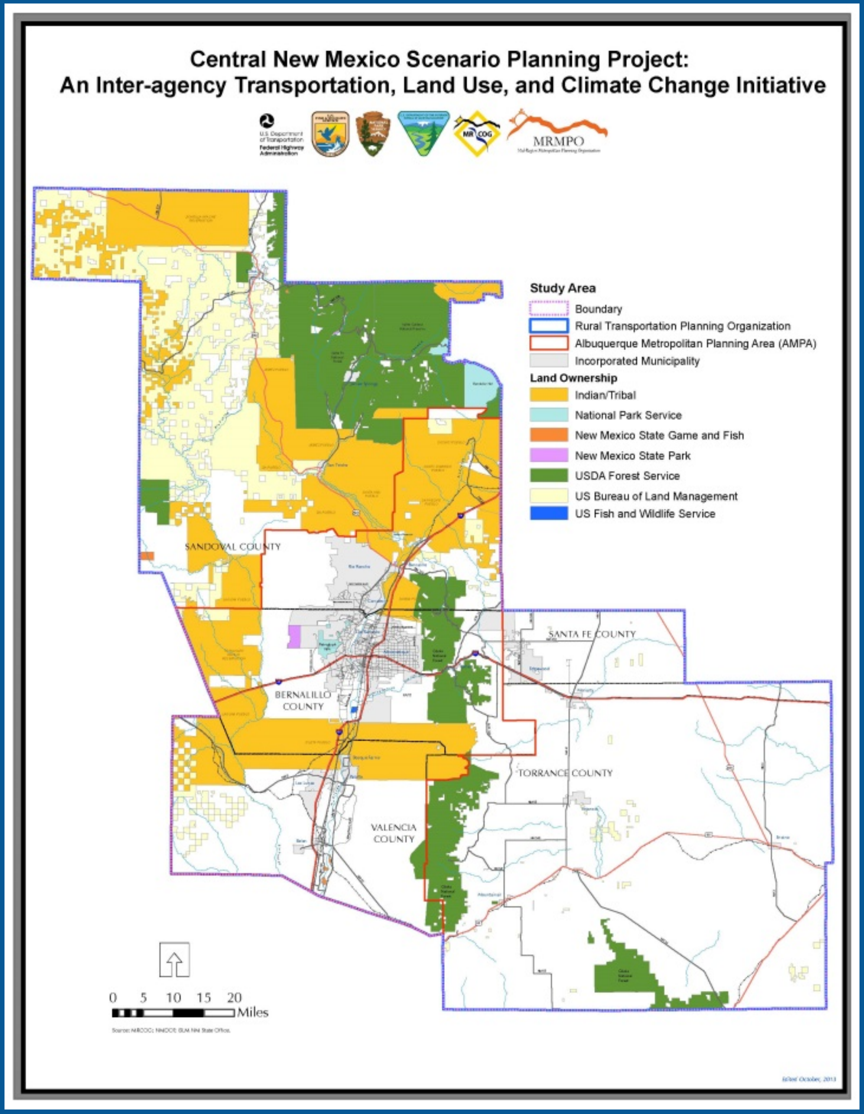
Albuquerque and Central NM

- 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’


U.S. Drought Monitor
July 30, 2013
Valid 7 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
L = Long-Term, typically >6 months (e.g. hydrology, ecology)
USDA
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
Released Thursday, August 1, 2013
Author: Brian Fuchs, National Drought Mitigation Center
http://droughtmonitor.unl.edu/

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?

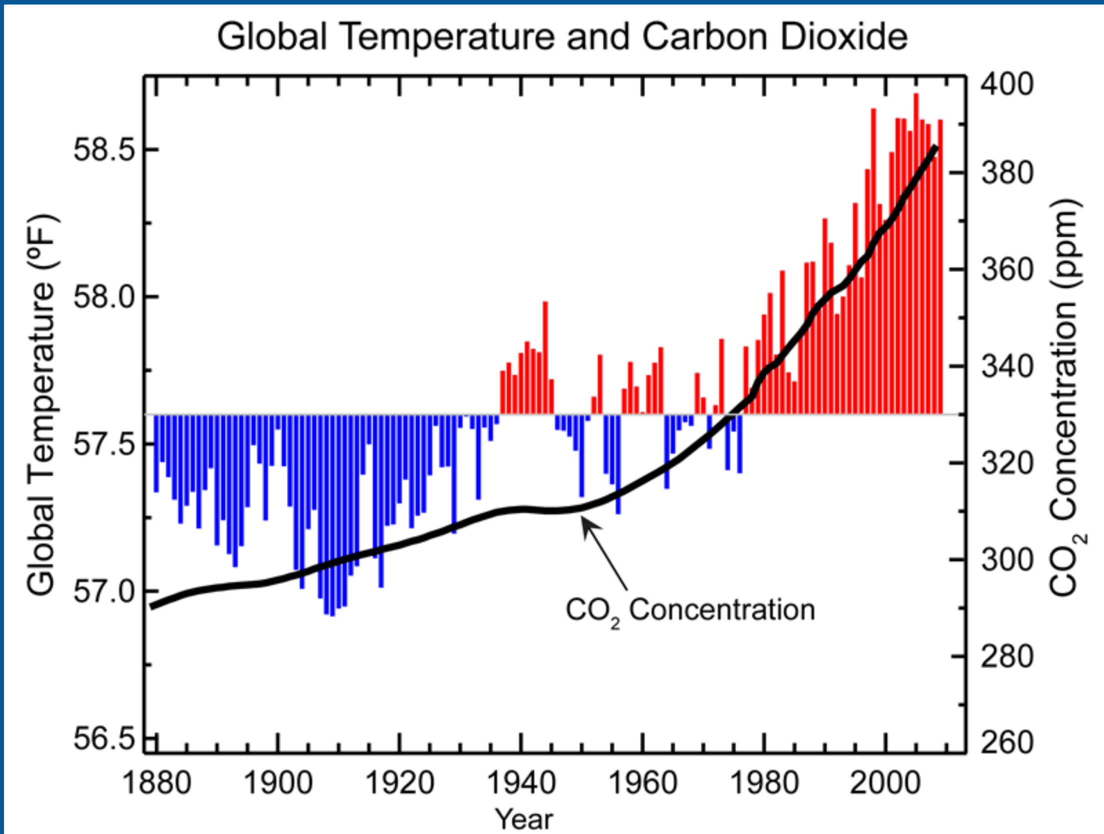
- Targeted density
- Mixed-use development
- Public transit
- Roadway efficiency improvements

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



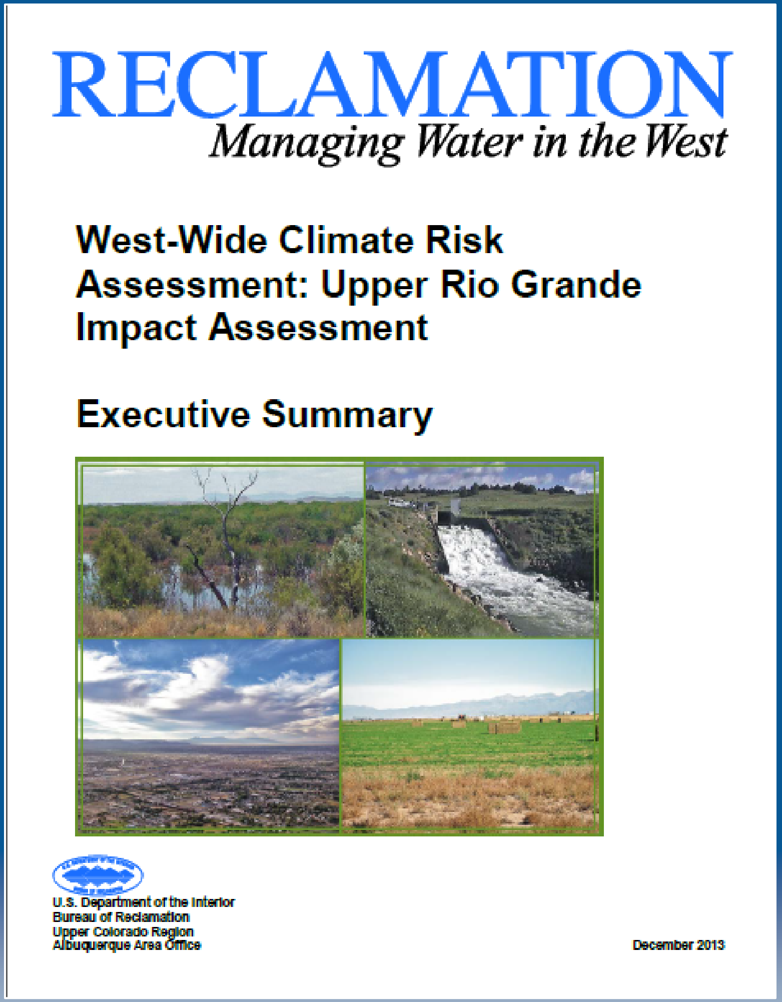
Source: NOAA

<u>Rio Grande Basin – 1971-2011</u>

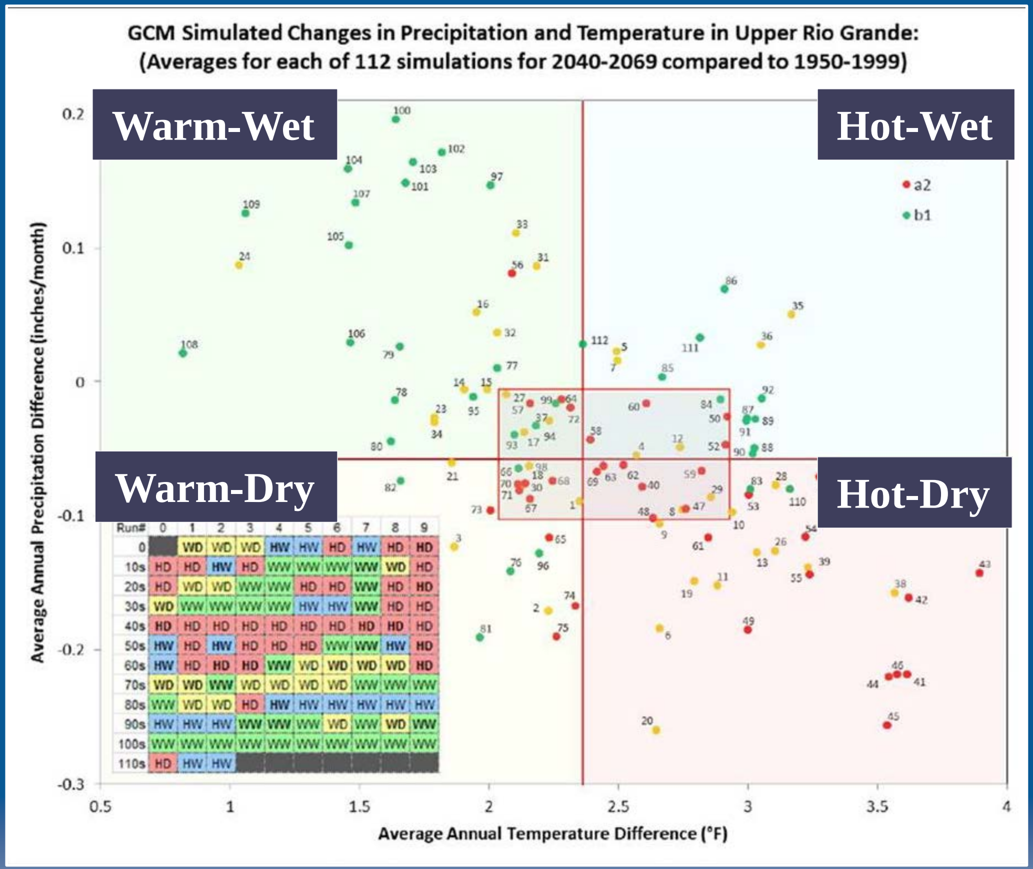
- Average temperature increased by 0.7^{0}F per decade
- Twice the global average

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



Upper Rio Grande Impact Assessment



- 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

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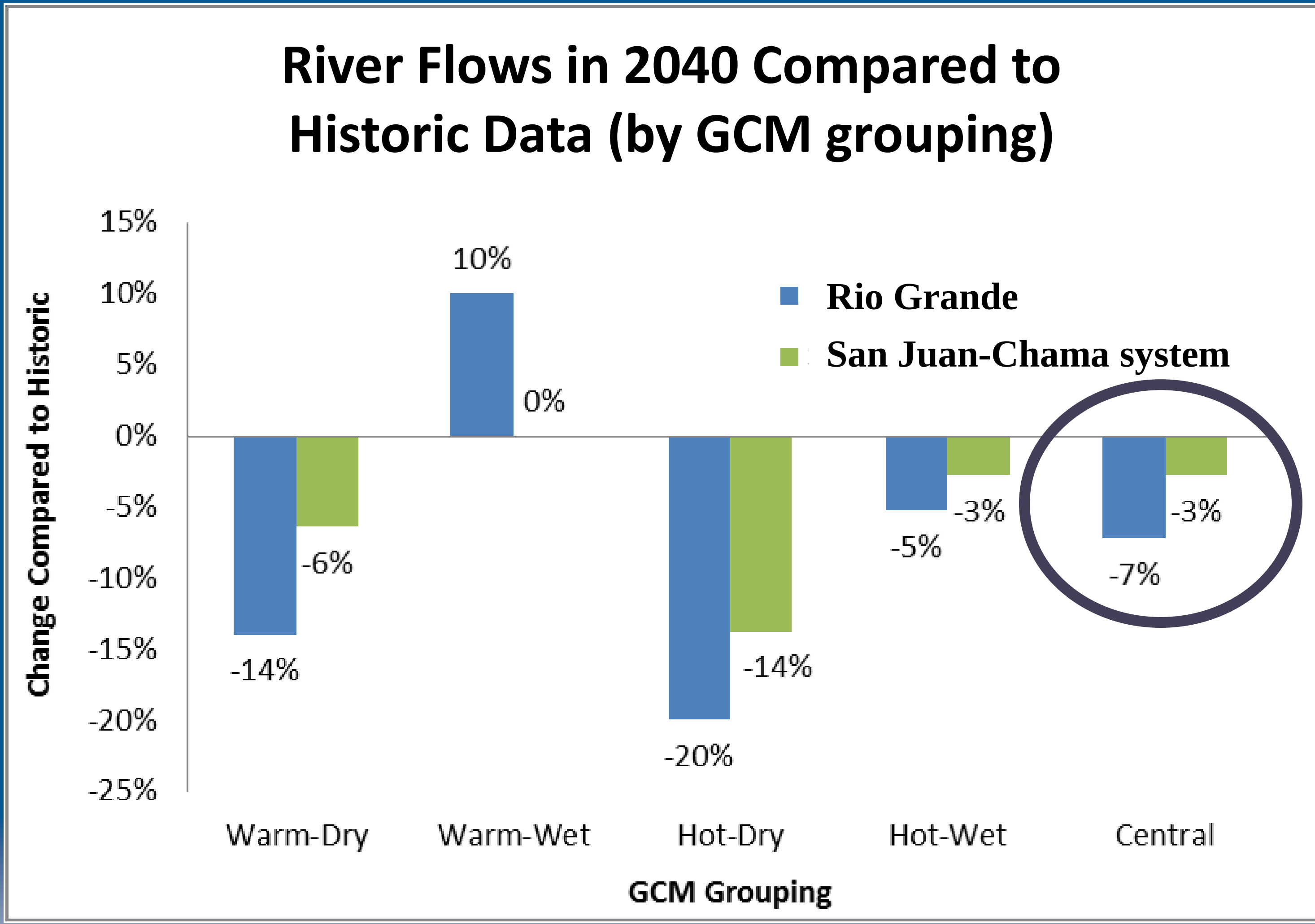
Water Availability in 2100

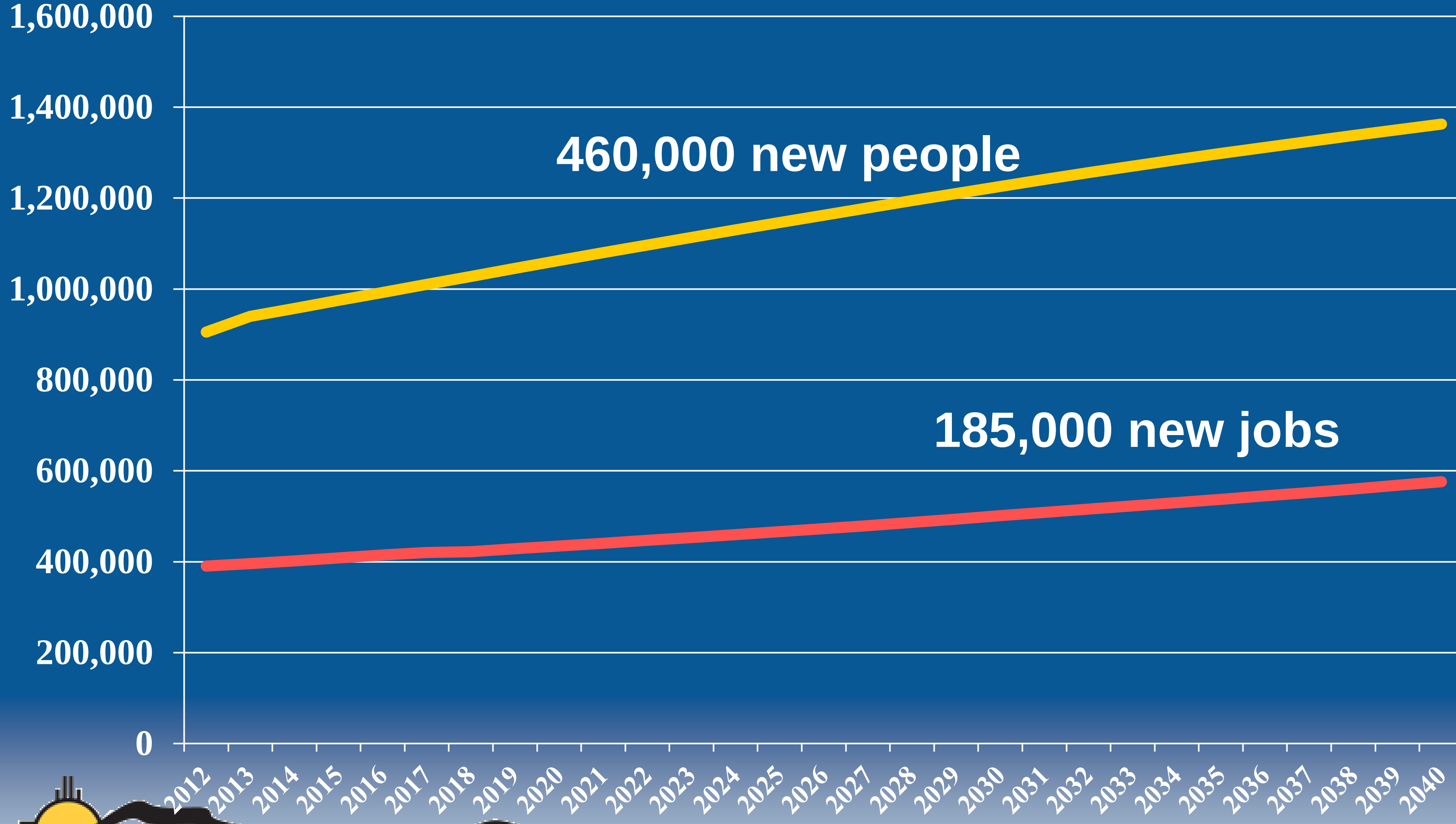
According to the Upper Rio Grande Impact Assessment:

- Rio Grande flows decrease by 1/3
- San Juan-Chama flows decrease by ¼
- Significant impacts to water supplies for Albuquerque area

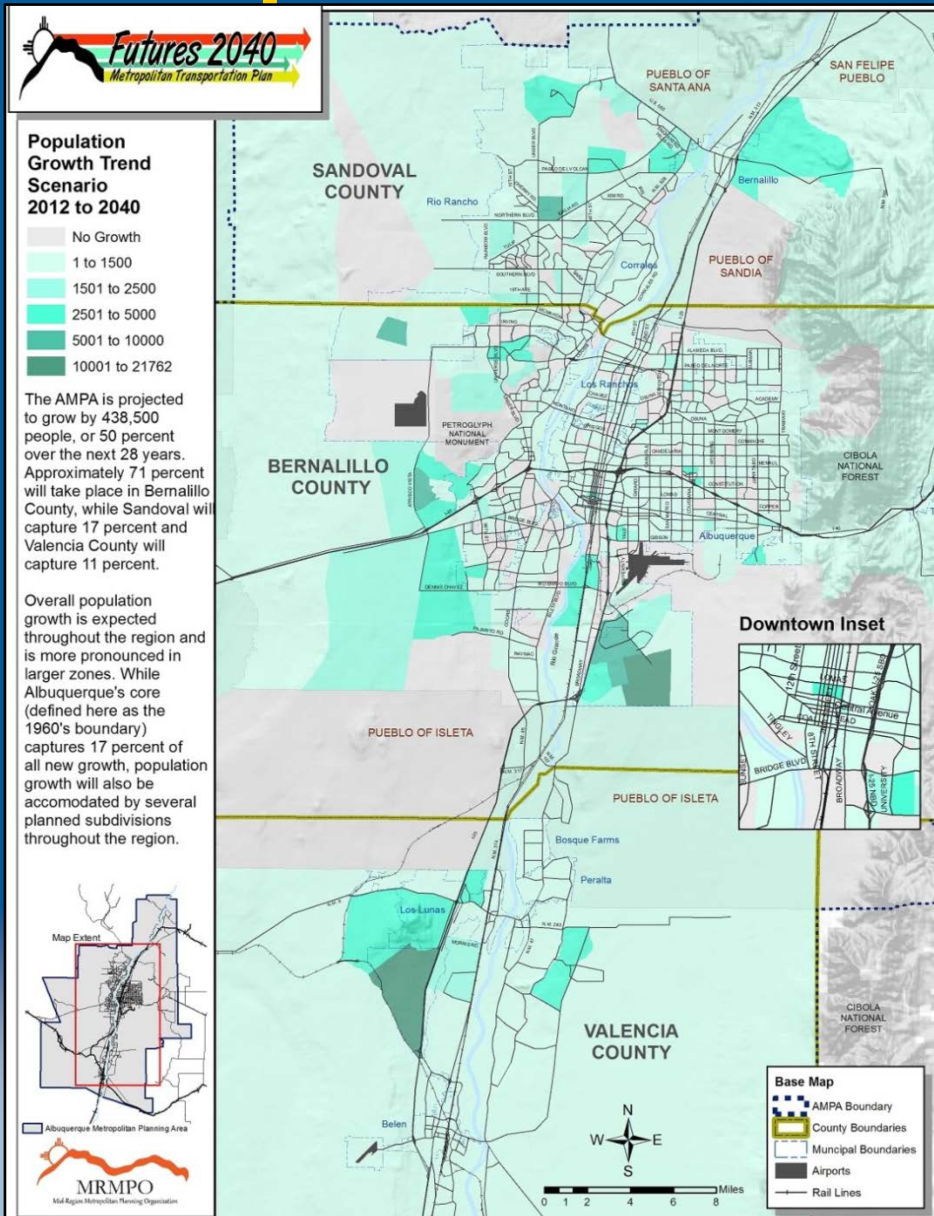
Water Availability in ABQ Area: 2040

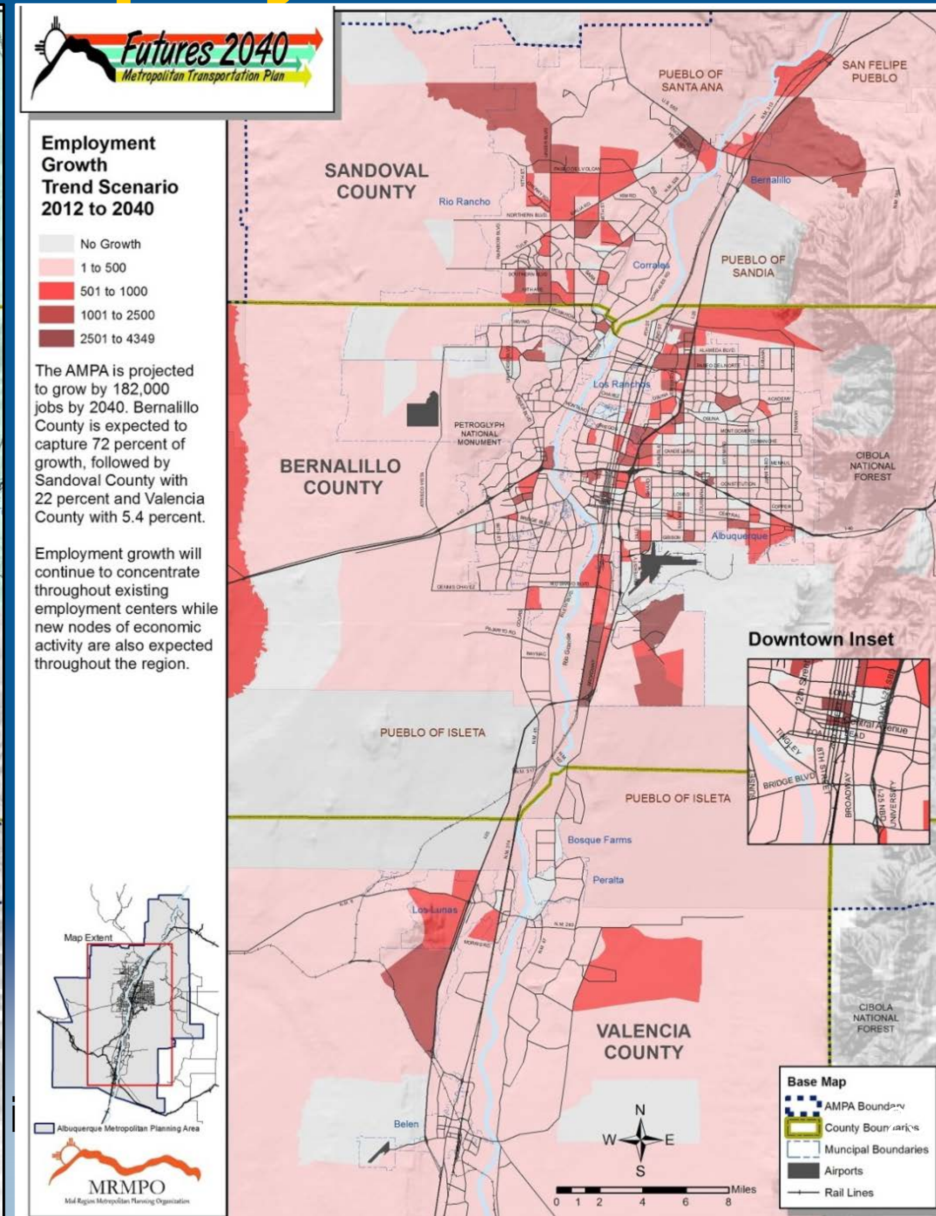


2040 Regional Forecast

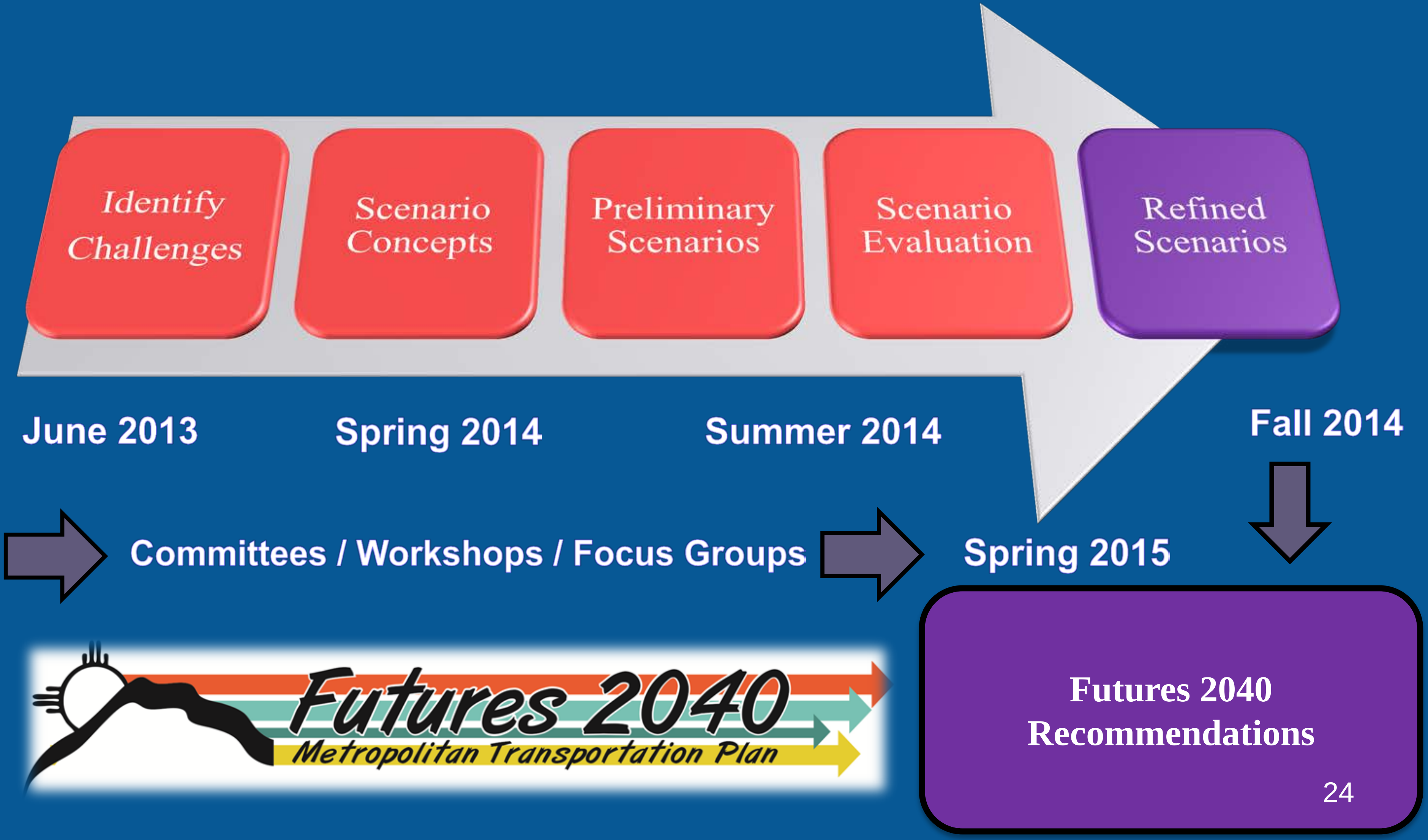


Trend Scenario:
Population and Employment 2040





Scenario Planning Process



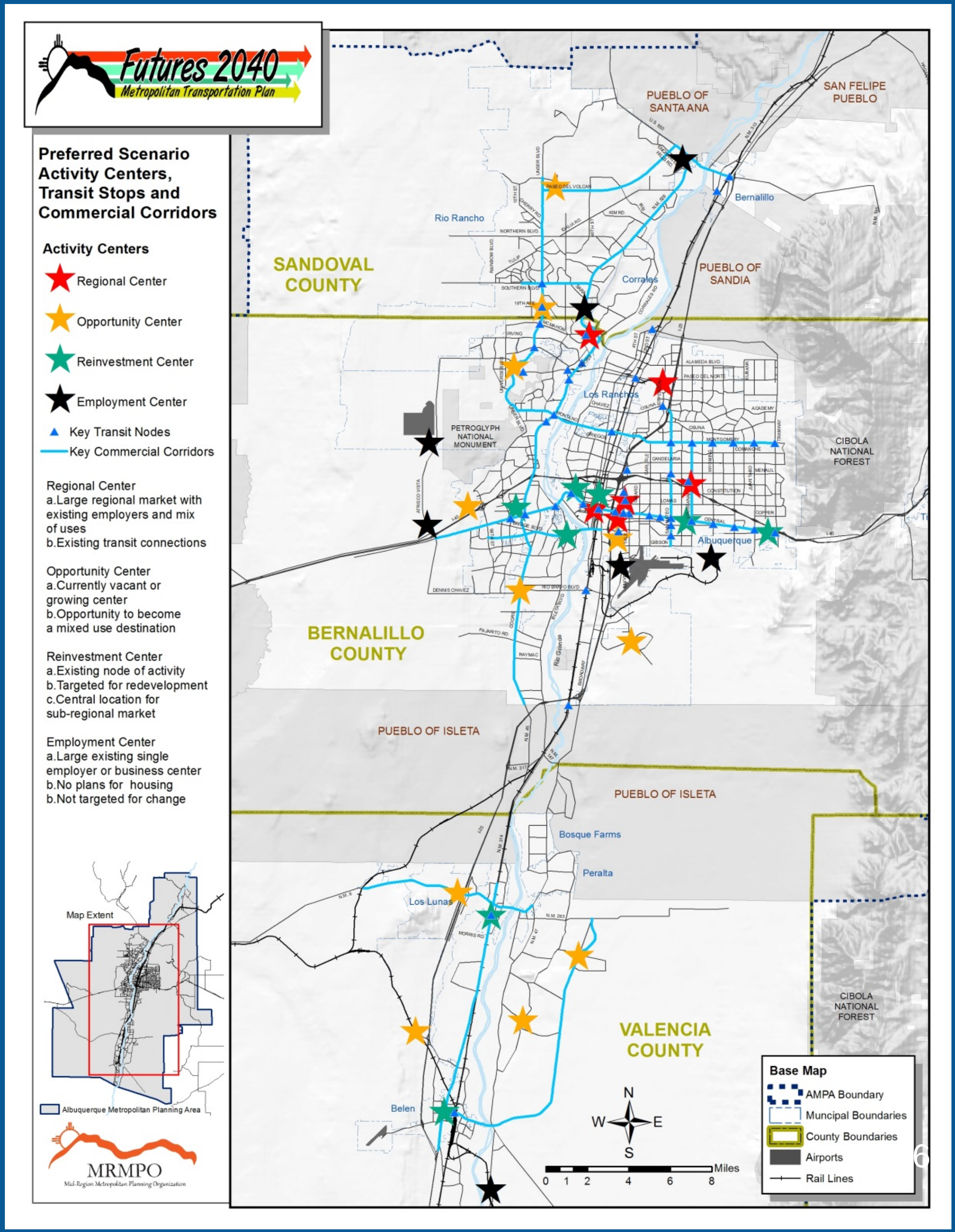
Futures 2040 Metropolitan Transportation Plan

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



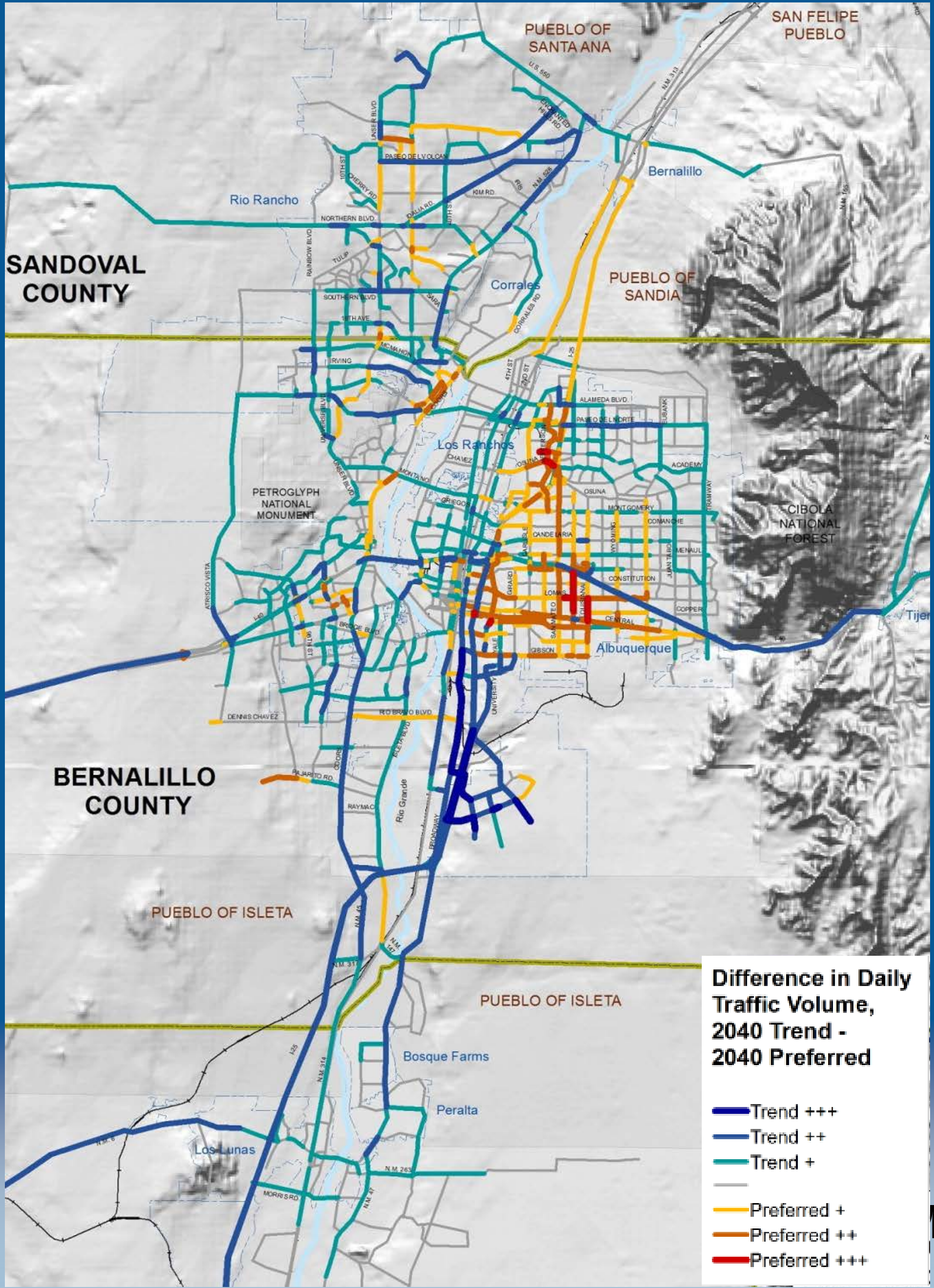
Scenario Planning Modeling Process

- 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

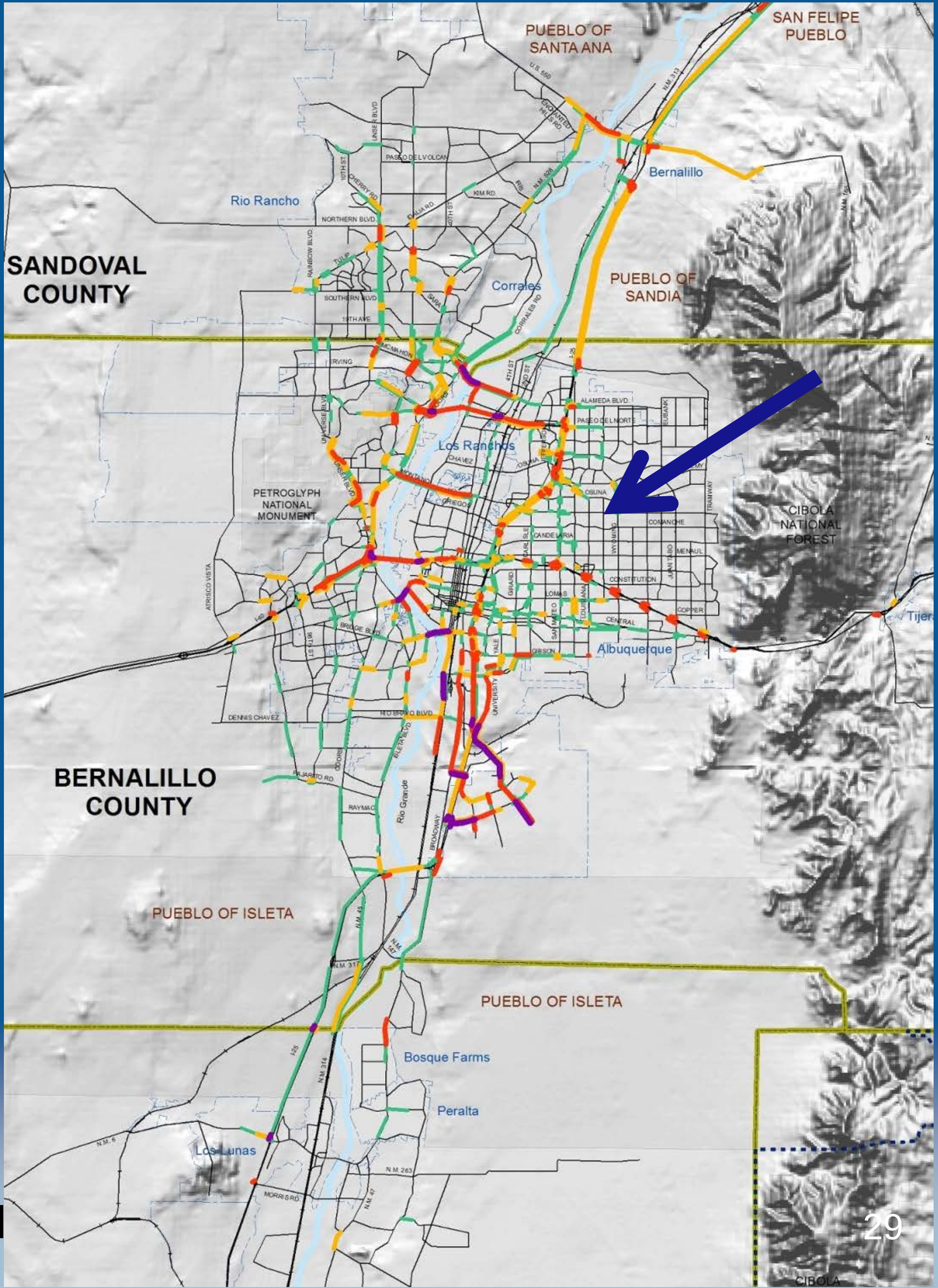
Scenario Planning Modeling Process

- 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

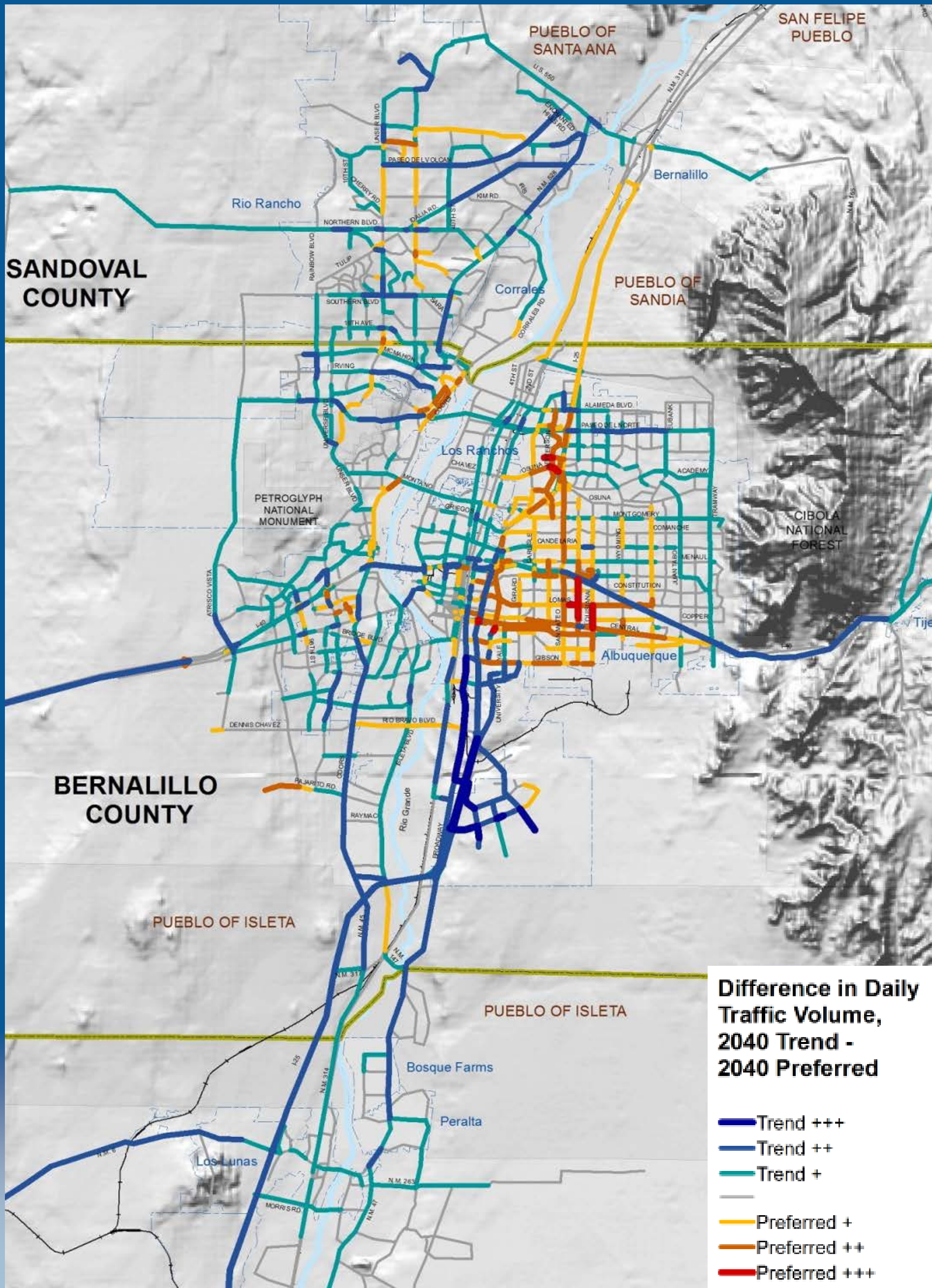
Volume: Trend vs. Preferred



Congestion: 2040 Preferred



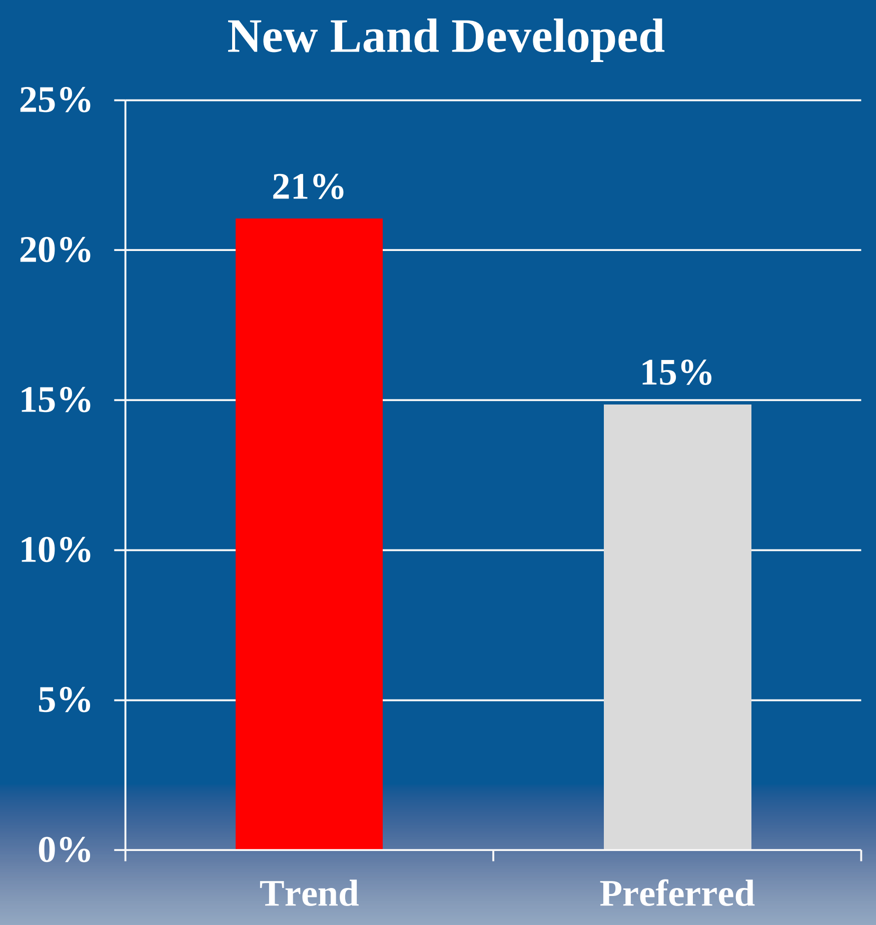
Differences: Trend vs. Preferred



- Average speeds ↑ 15%
- Commute time ↓ 18%
- Hours traveled ↓ 17%
- Miles traveled ↓ 4%

Development Footprint

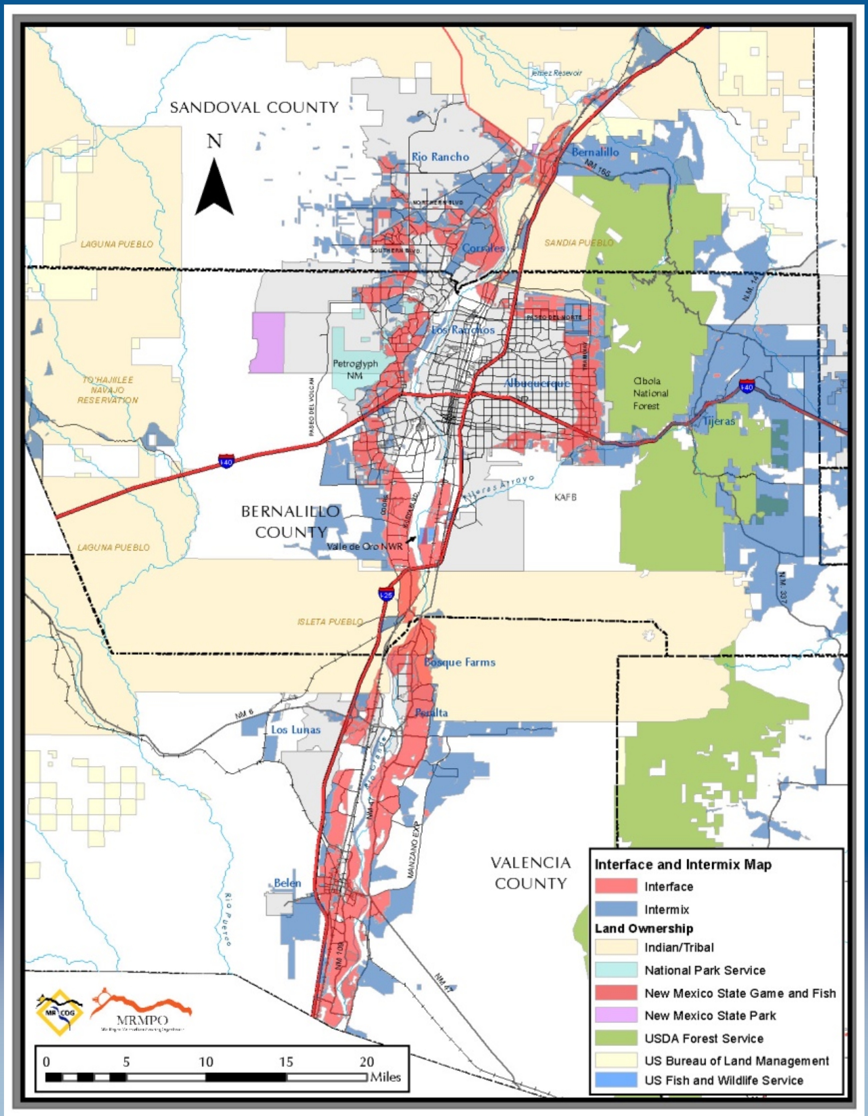
- 5% reduction in overall number of acres consumed in 2040 in the Preferred Scenario compared to the Trend Scenario
- 12,600 fewer acres of residential development



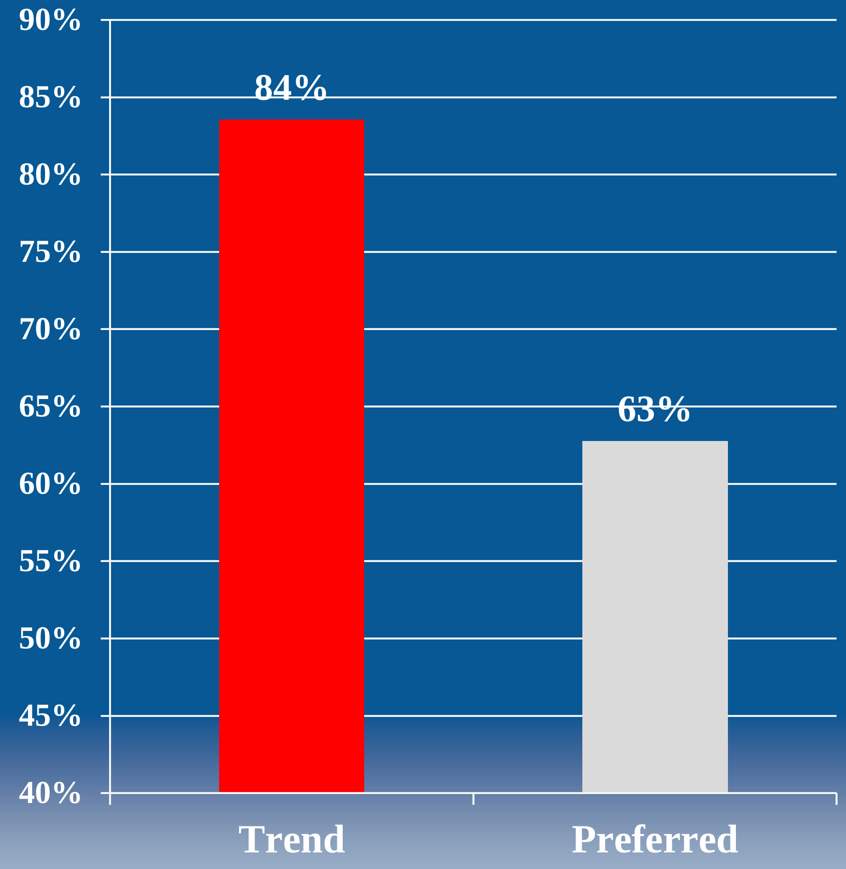
Climate Change-Related Evaluation Measures

- Wildland-Urban Interface (wildfire risk area)
- FEMA-designated 100-year floodplains
- Crucial Habitat Assessment Tool
- Water consumption
- CO_2 emissions

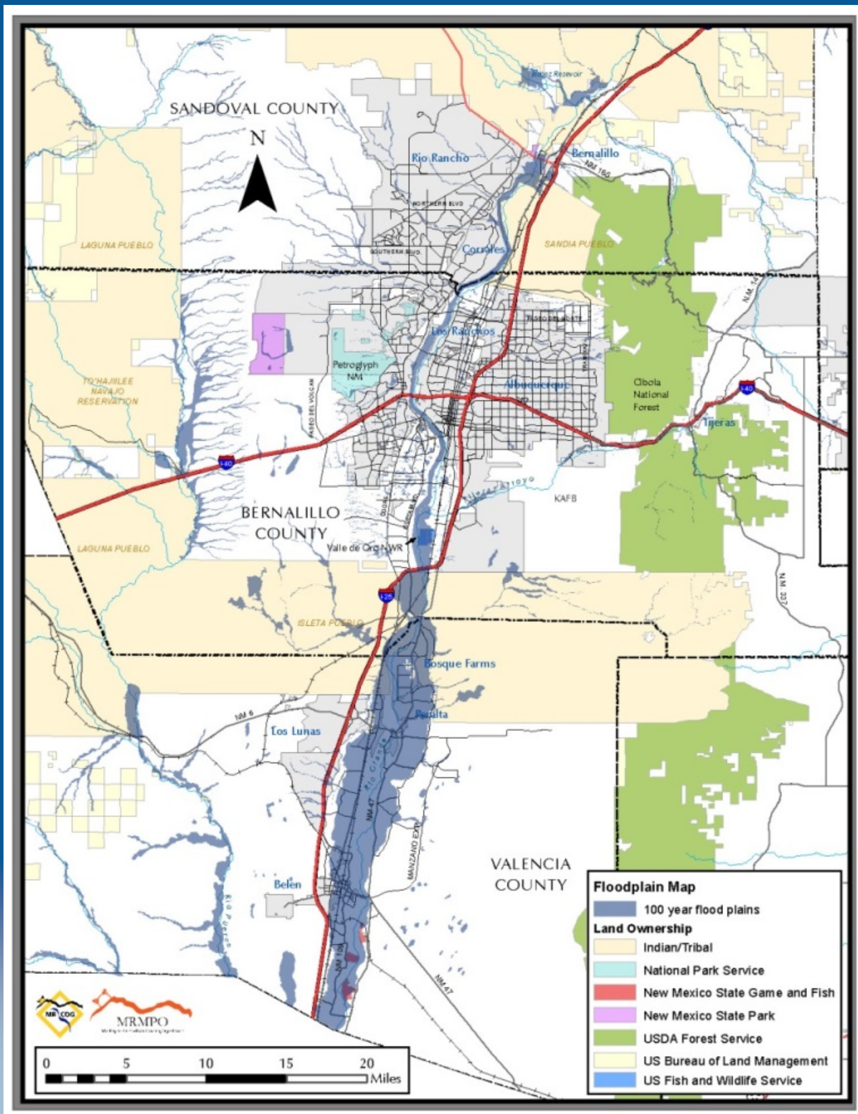
Wildland-Urban Interface



Housing + Employment Growth – Intermix Area Only



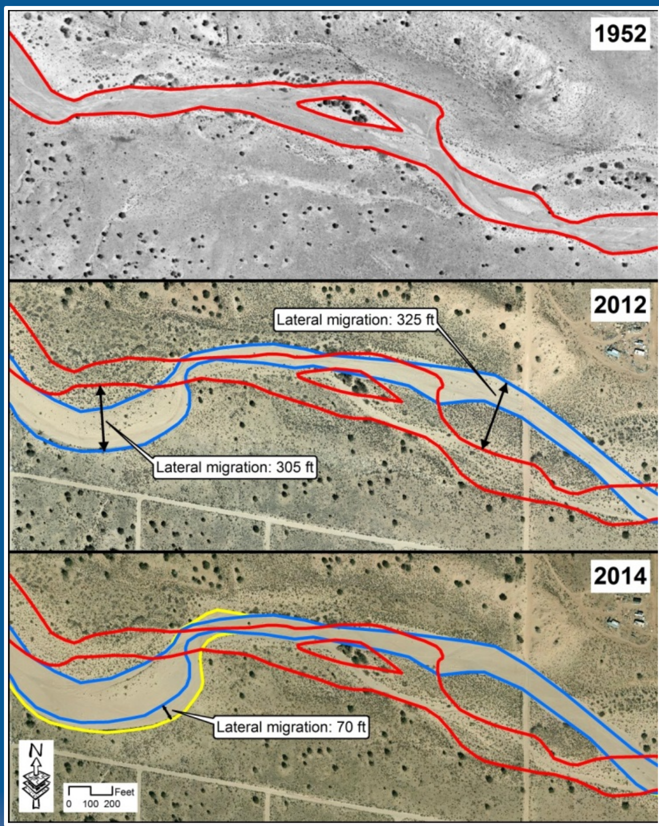
100-Year Floodplains



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

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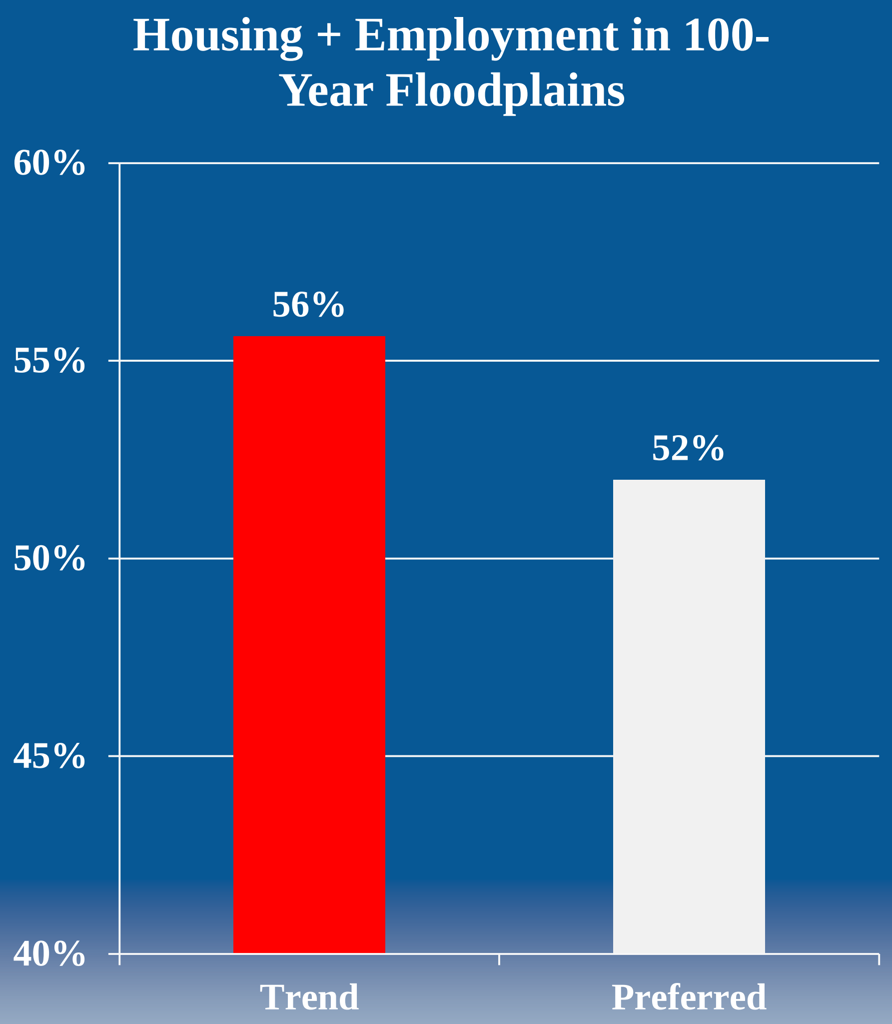
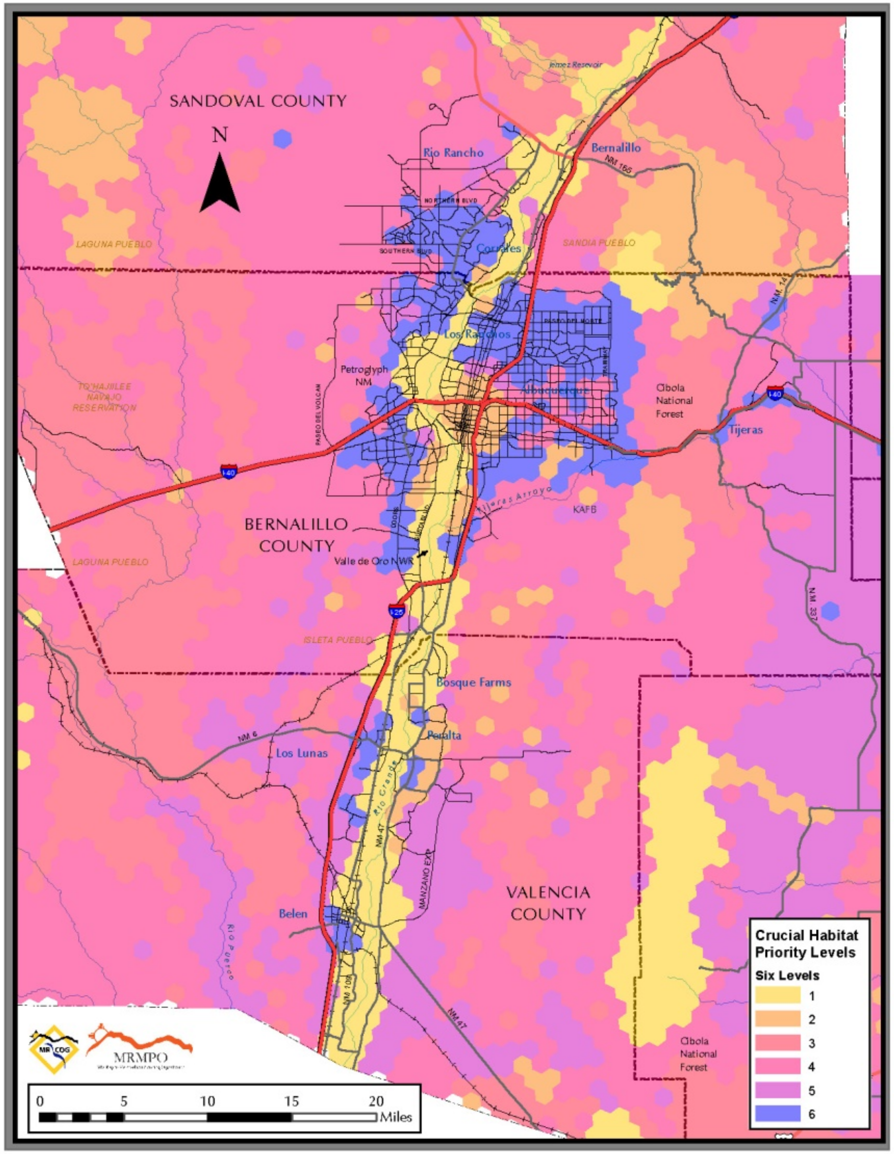
High Flood Risk Area

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

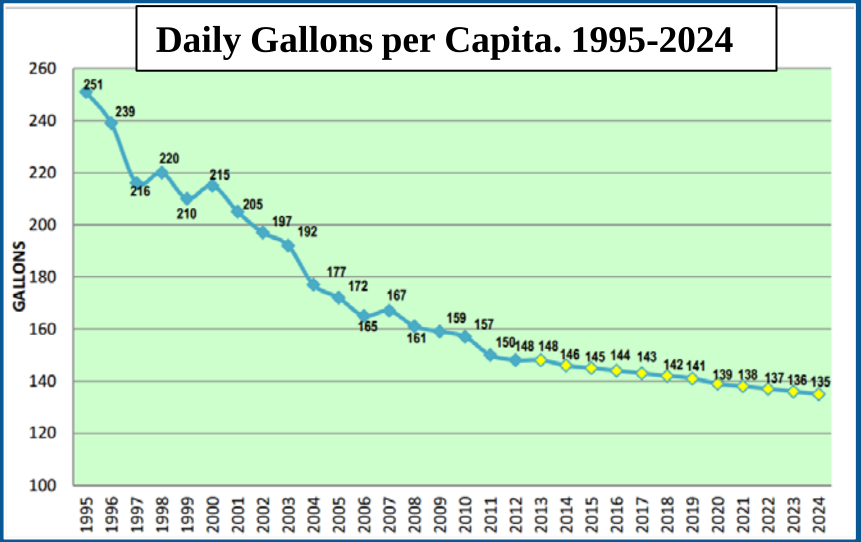


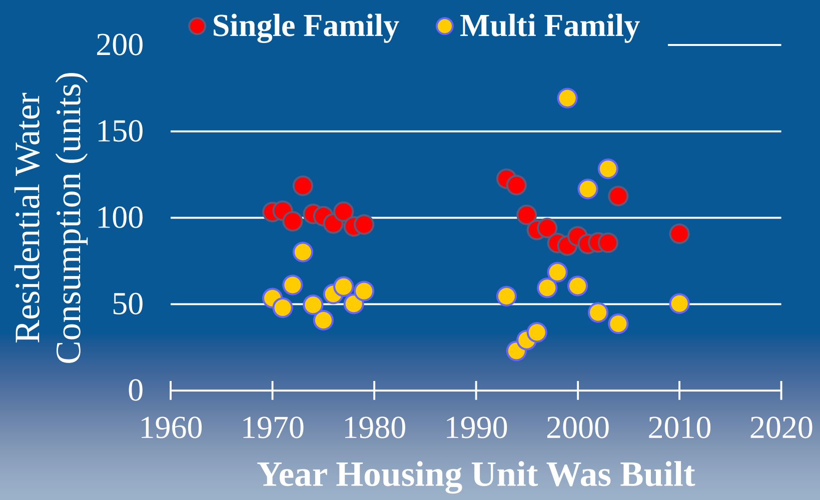
- Western Governors Association tool – ranking for 1-mi^2 hexagons
- Overlay land use with crucial habitat scores
- Challenges:
  - Most critical locations are in the urban core - Lowest risk areas also those subject to potential sprawl
- Not much difference between scenarios
- Conclusion: Better to 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

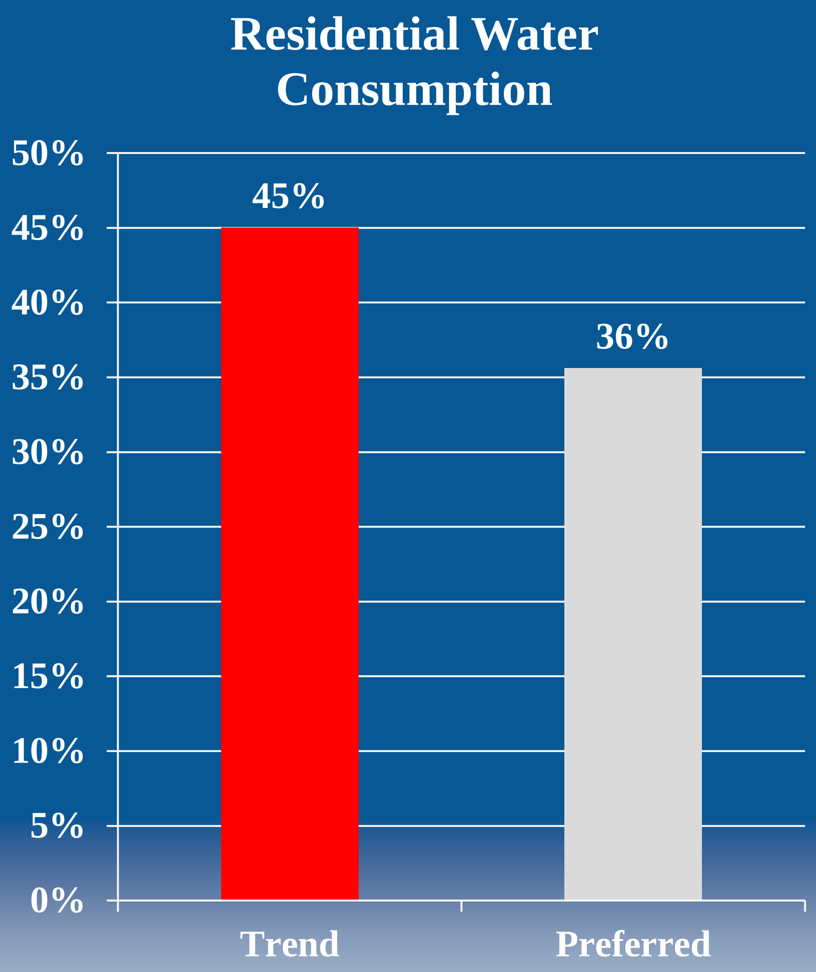
Source: Albuquerque Bernalillo County Water Utility Authority





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



Emissions Reduction Strategies

Preferred Scenario Components:

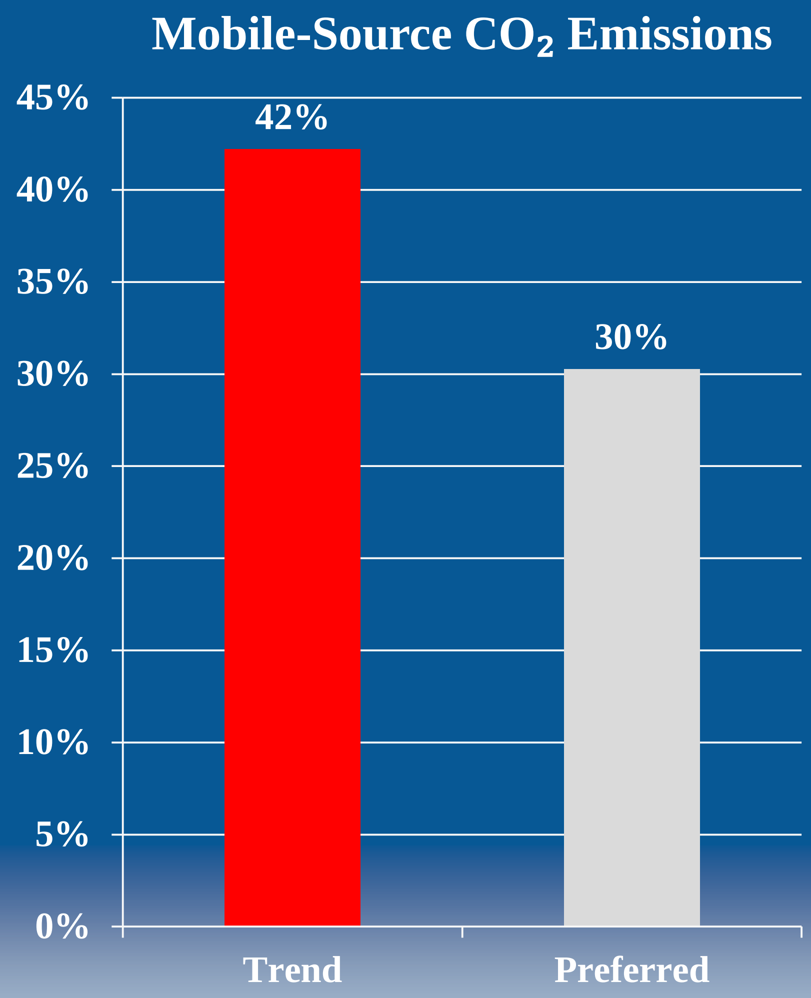
- Expanded transit service
- Transit-oriented development
- Land use / increased density
  - Zoning
  - Infill
  - Development incentives

- Many other strategies are discussed in the 2040 MTP but could not be included in modeling environment
- Additional analysis conducted by project team

GHG Emissions

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



Changes in Preferred Scenario Compared to Trend Scenario

New Land Developed	-5%
Vehicle Miles Traveled	-4%
CO_2 Emissions	-8%
Residential Water Consumption	-6%
Growth in Flood Risk Areas	-2%
Growth in Fire Risk Areas	-10%
Development in Crucial Habitat Areas	-1%

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

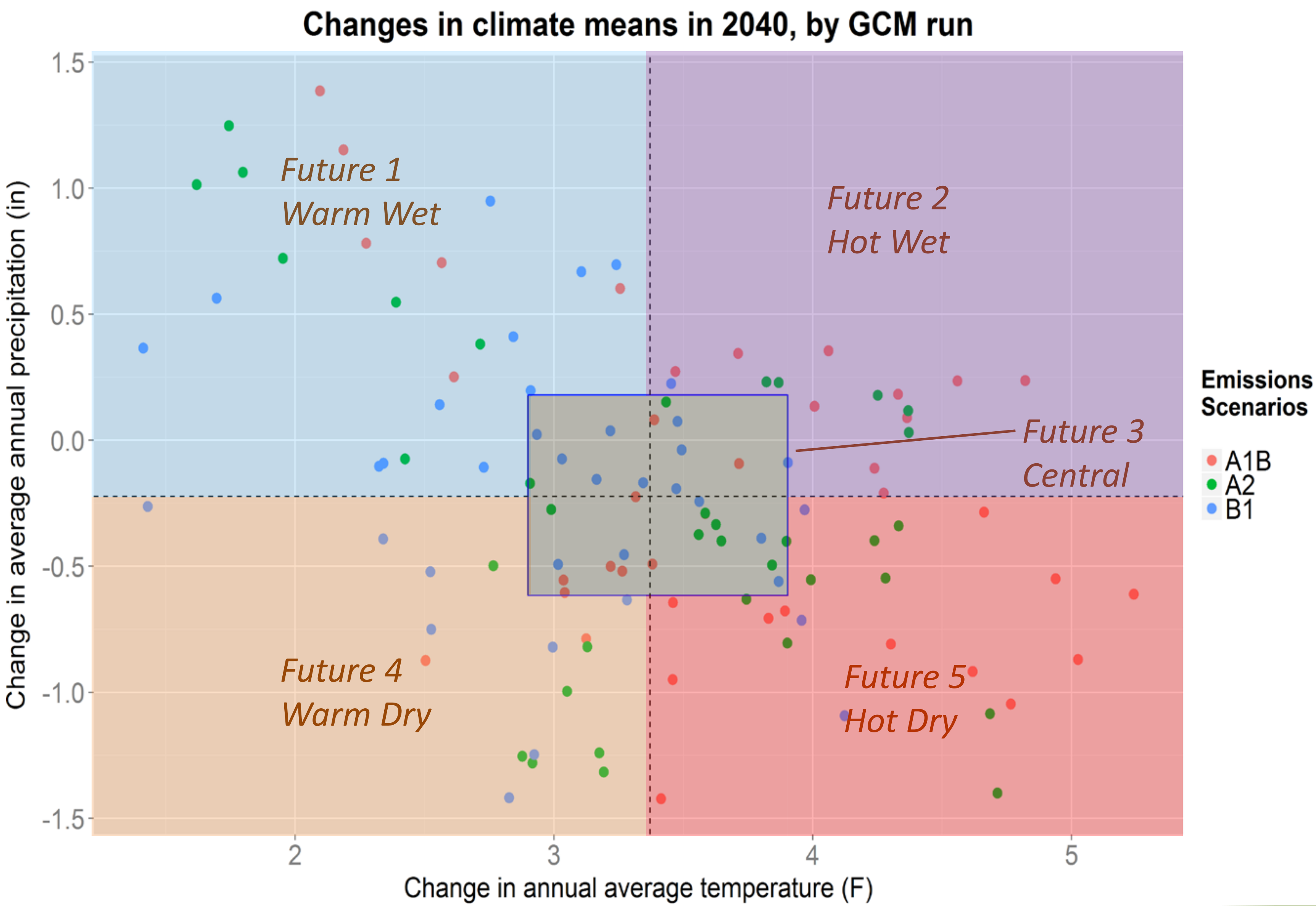
- Climate change as framing device for scenario planning and a way to introduce new measures
- Connection between transportation, land use, and water
- Create a sense of urgency
- Agency connections
  - Project intended to integrate federal-land management areas into MPO planning
  - New partnerships: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

Downscaled Climate Data Processing Tool

Variables
Precipitation (mm/day)
Maximum daily temperature (°C)
Minimum daily temperature (°C)
Average daily temperature (°C)—*derived by averaging max & min*
Average daily wind speed

Projections Range
1950-2099

- 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)

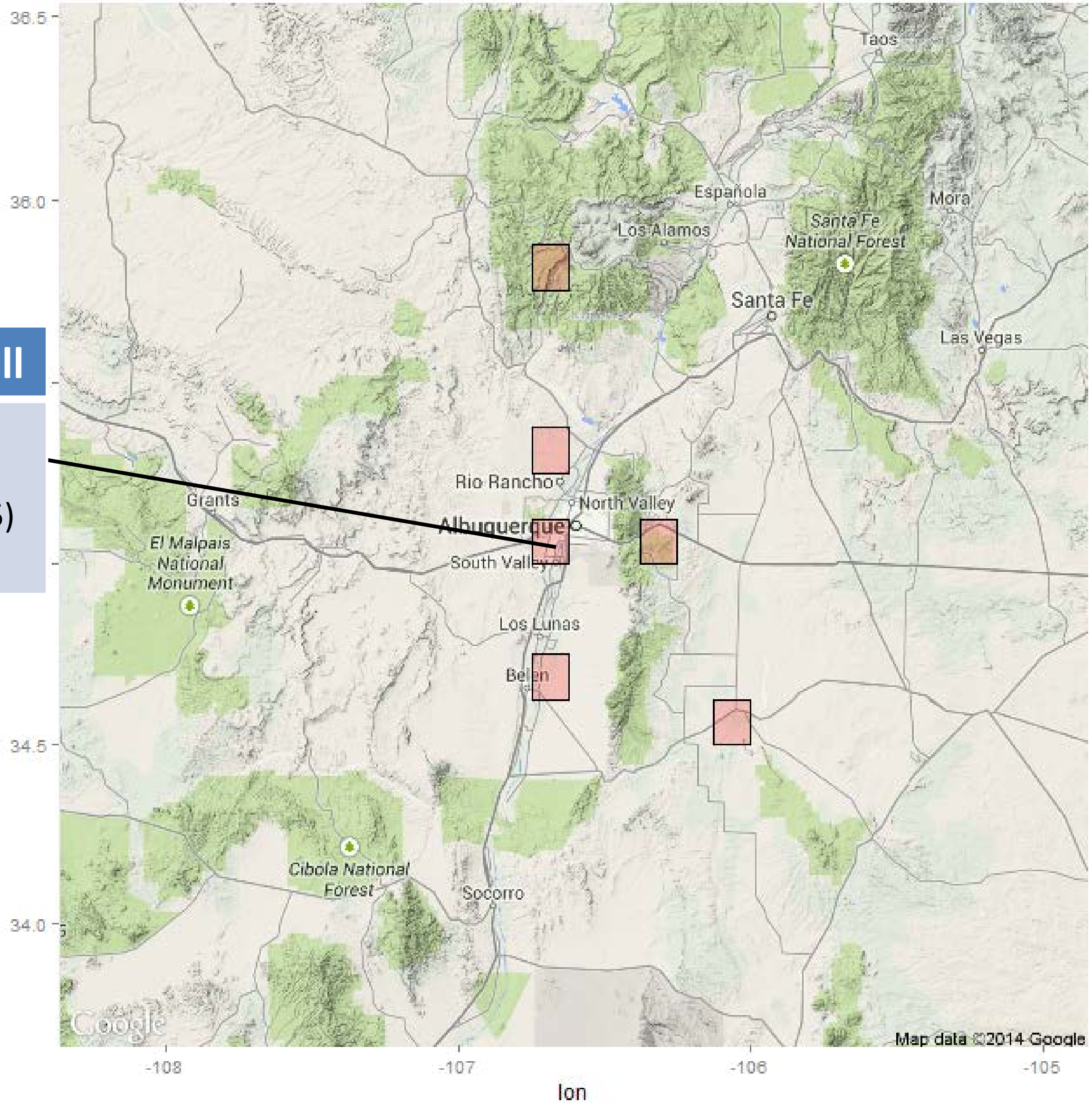


Changes in climate means in 2040, by GCM run
Future 1
Warm Wet
Future 2
Hot Wet
Future 3
Central
Future 4
Warm Dry
Future 5
Hot Dry
Emissions Scenarios
A1B
A2
B1
Change in average annual precipitation (in)
Change in annual average temperature (F)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
2
3
4
5

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

Wetter

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%)

Hot

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%)

Temperature

Hotter

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%)

Precipitation

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%)

Drier

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 #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.

Grid Cell #3

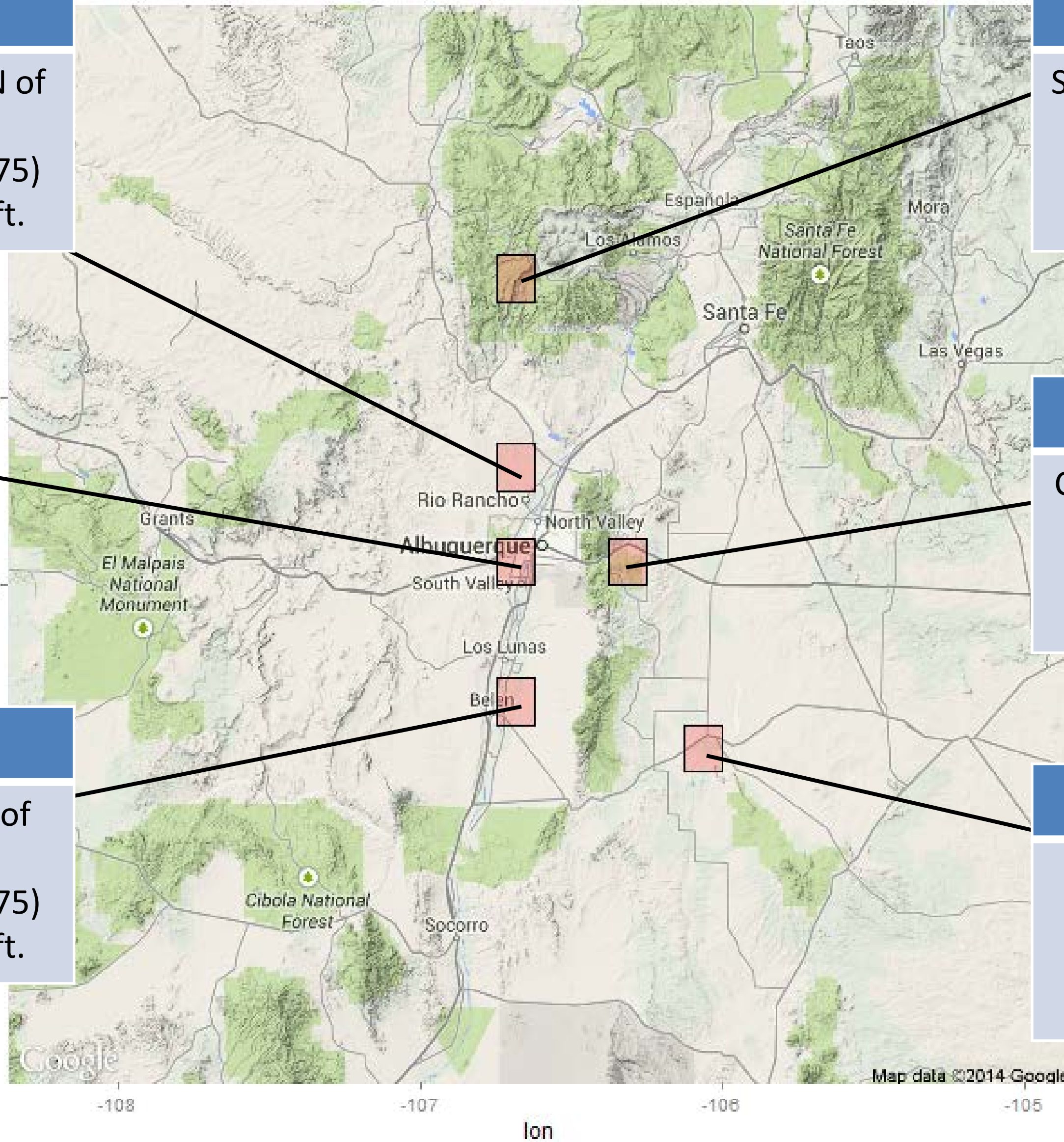
Cibola National Forest, E of Albuquerque
(35.0625, -106.3125)
Elevation: 7,025 ft.

Grid Cell #2

Los Lunas area, S of Albuquerque
(34.6875, -106.6875)
Elevation: 5,005 ft.

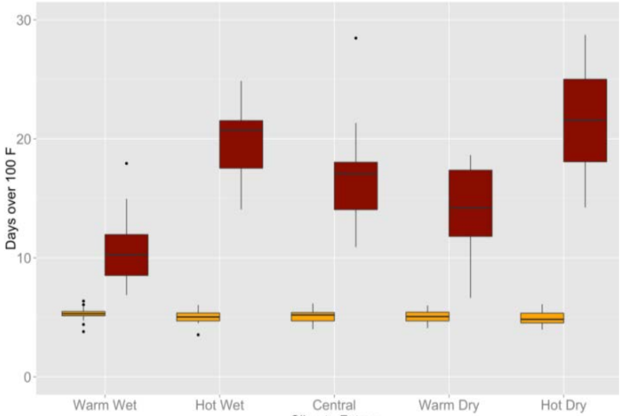
Grid Cell #4

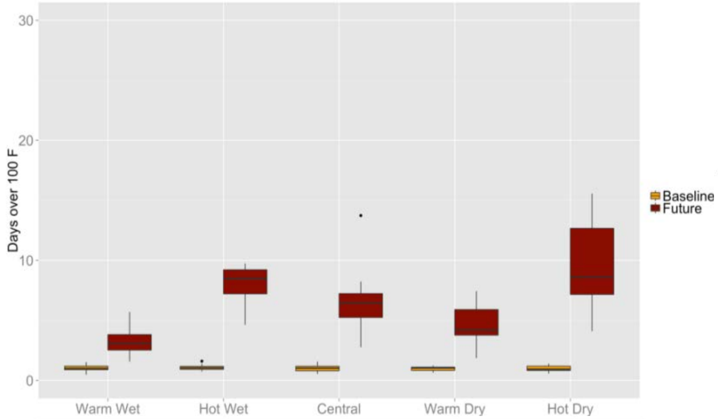
General desert area, SE of Albuquerque
(34.5625, -106.0625)
Elevation: 6,155 ft.



Total Days Over 100°F in Baseline (1950-1999) and 2040 (2025-2055 average)

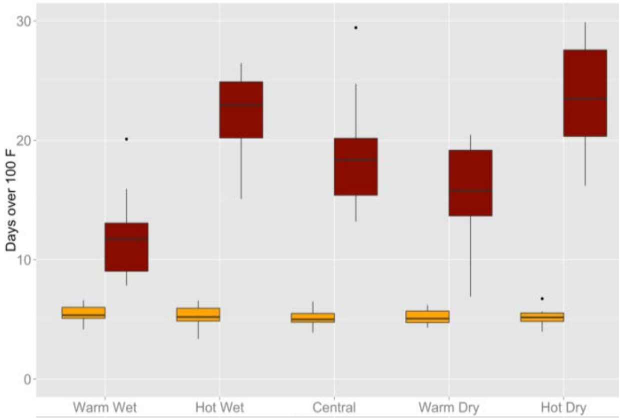
Original Grid Cell

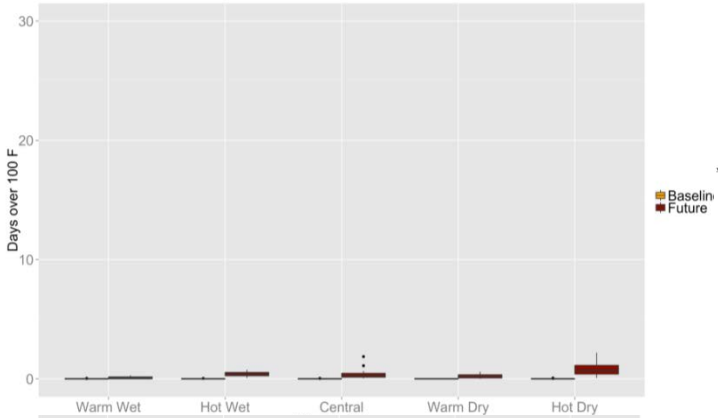




Grid Cell #1

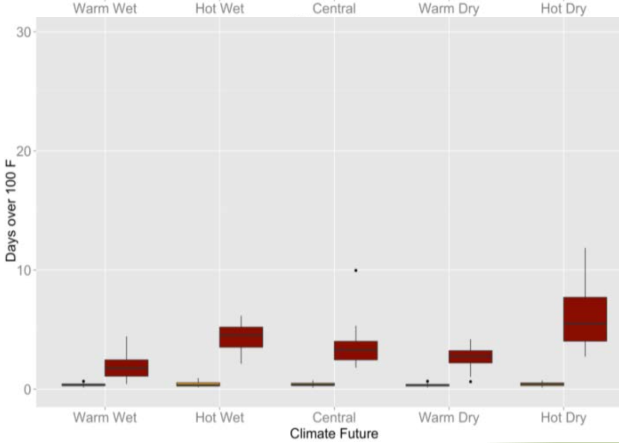
Grid Cell #2

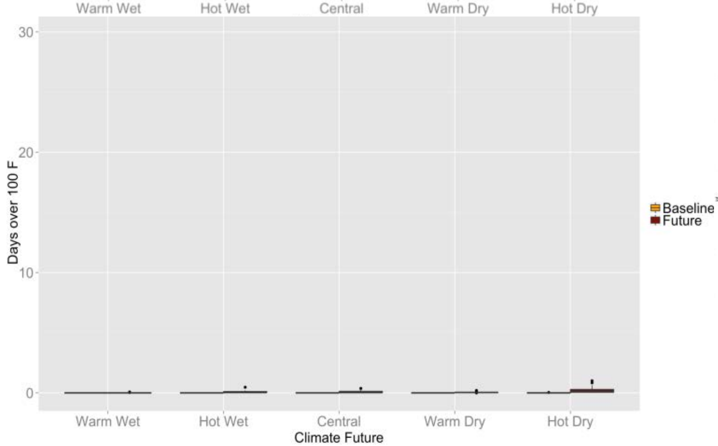




Grid Cell #3

Grid Cell #4





Grid Cell #5

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

Strategy	GHG Mitigation Potential	Analysis Capability
Analysis Completed During the Scenario Planning Phase		
Zoning changes	●●●●● L	●●●●● U
Infill development	●●●●○ L	●●●●○ U
Transit oriented development	●●●●○ L	●●●●○ U,C
Improving public transportation	●●●○○ S	●●●○○ C
Higher Priority Strategies Evaluated		
Urban growth boundaries	●●●●● M	●●●●● U
"Wheels" tax (VMT charging) & Gas Tax	●●●●● S	●●●●○ C
Bicycle and pedestrian infrastructure improvements	●●●○○ S	●●○○○ O,P,Q
Incident management	●●○○○ S	●○○○○ Q
Traffic signal enhancement	●●●○○ S	●●●○○ C,P
Establishing roadway connectivity standards	●●●○○ L	●●●●○ C
Lower Priority Strategies to be Discussed in Final Report		
Bike sharing	●○○○○ S	●○○○○ Q
HOV facilities	●○○○○ M	●○○○○ Q,P
Building design standards	●●○○○ L	●○○○○ Q
Establishing a complete streets policy	●●○○○ L	●○○○○ Q
Road pricing (HOT lanes/congestion charging)	●●●○○ S	●●○○○ C,P
Parking management	●●●○○ S	●●●○○ C
Car sharing	●○○○○ S	●○○○○ Q
Ride sharing	●○○○○ S	●●●○○ Q,C
Travel demand management-educational	●○○○○ S	●○○○○ Q
Travel demand management-transit incentives	●●●○○ S	●●○○○ Q,P
Intersection improvement	●○○○○ S	●●●●○ P,C
Electric vehicle infrastructure support	●●○○○ M	●○○○○ Q,M
Heavy-duty vehicle retrofit	●○○○○ M	●●●●○ Q,M

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

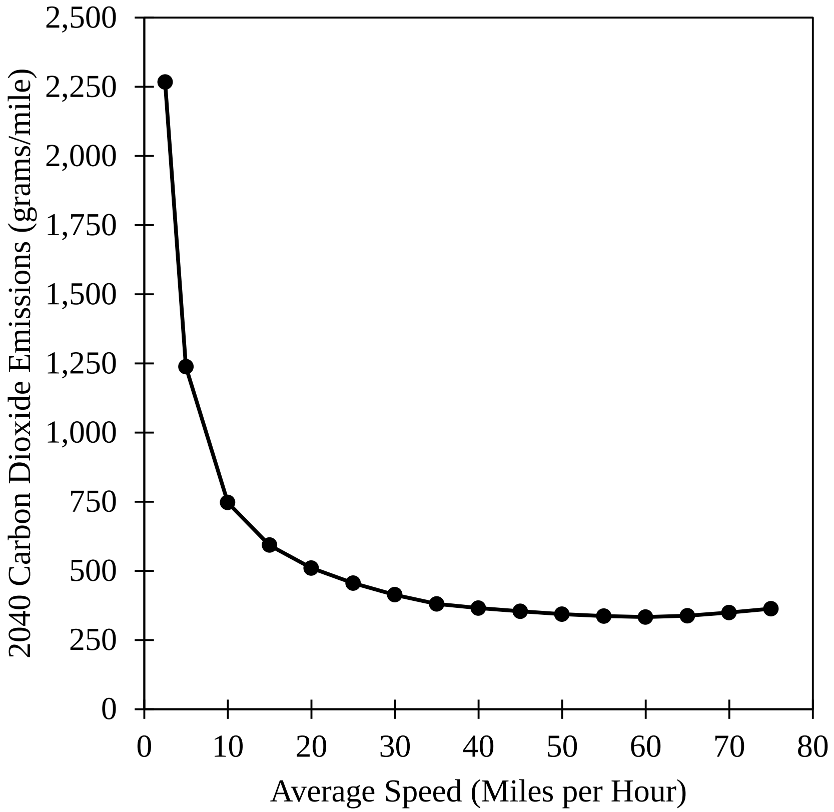
Additional VMT Tax	Equivalent Gas Tax Increase ($/gallon)	Daily VMT per Capita	CO_2-eq (tonne/day)	% Change in CO_2-eq
$0.00	$0.00	20.0	13,352	0%
$0.03	$0.62	19.4	12,572	-6%
$0.06	$1.24	18.5	11,959	-10%
$0.12	$2.47	17.1	10,968	-18%
$0.25	$5.15	15.0	9,616	-28%
$0.50	$10.30	12.3	7,955	-40%

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



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

	CO_2-eq (tonnes/day)				
Road	**Before**	**After**	**Change**	**% Change**	**% of 2040 Total**
Alameda	60.8	57.2	-3.6	-5.9%	-0.03%
Montgomery/Montano	288	276	-12.0	-4.2%	-0.09%
Coors	442	426	-15.6	-3.5%	-0.12%

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

Neighborhood	Area (km^2)	Intersections	Intersection Density	% Change in VMT from SW Albuquerque [a]
SW Albuquerque	0.78	51	65.6	0.0%
NW Albuquerque	0.71	50	70.6	-0.9%
University Area	0.67	56	83.9	-3.3%
Downtown Albuquerque	0.45	52	116.8	-9.4%

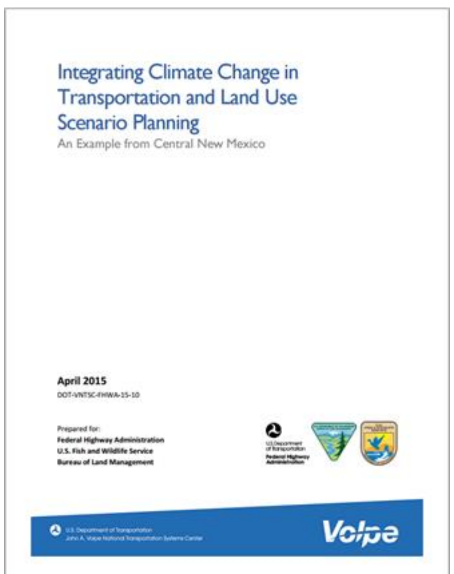
Conclusions from Additional Analysis

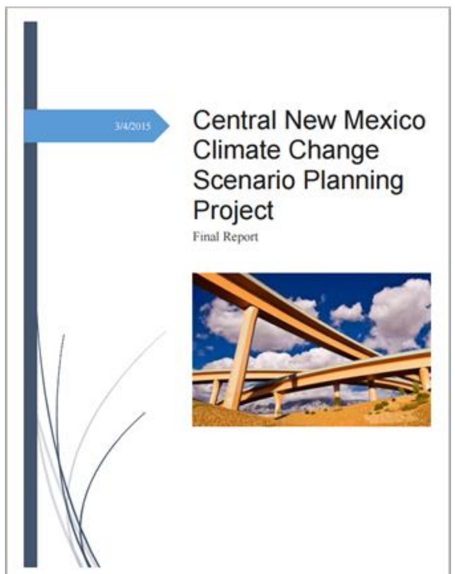
- Additional GHG mitigation strategies will result in lower GHG emissions than what was included in the preferred scenario

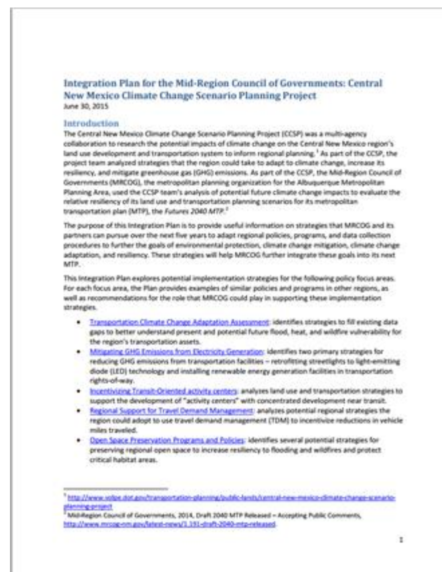
	CO2-eq Reduction	
Growth Boundary	512	3.8%
VMT Tax 0.005 per mile[a]	107	0.8%
VMT Tax 0.03 per mile	780	5.8%
VMT Tax 0.12 per mile	2,384	17.9%
Bicycle Infrastructure	49.1	0.4%
Traffic Signal Enhancement	27.6	0.2%

Resources Available

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







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