TREES AND OZONE AIR POLLUTION

Air Quality Issues in the Rocky Mountain Region

November 17, 2009

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PREVIEW

- IES and The Tree Project
- Ozone Air Pollution and Strategic Urban Forestry
- Policy implications
- Next Steps
- Conclusion
- Additional Resources

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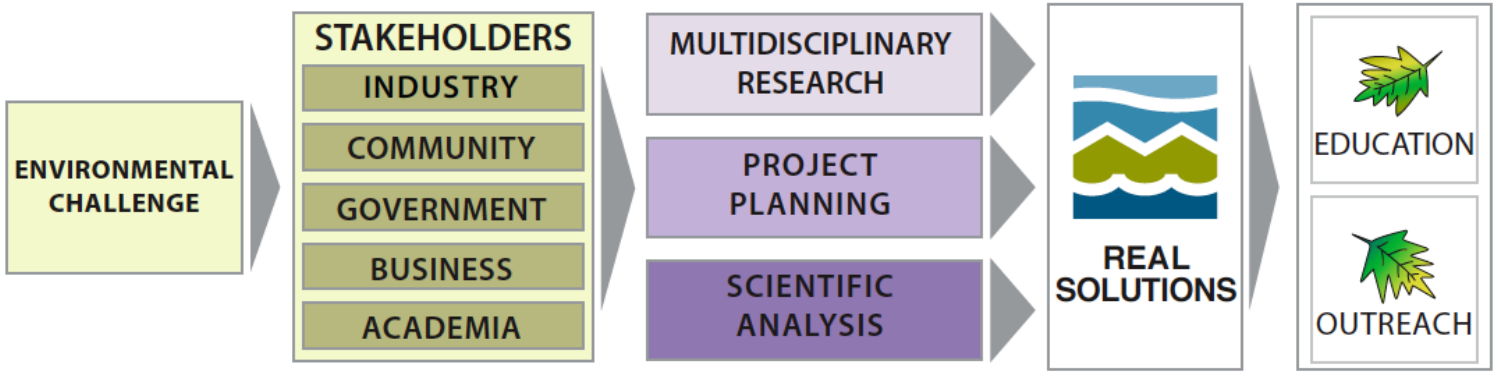
Mission

The Institute for Environmental Solutions is an independent non-profit organization that engages stakeholders to deliver technically sound solutions to complex environmental and health problems -- without unwanted side effects.

Approach



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THE TREE PROJECT

- Identifying how trees can optimize:
  - Air quality
  - Energy conservation
  - Carbon sequestration
  - Water conservation
  - Stormwater management
- Pilot city: Golden

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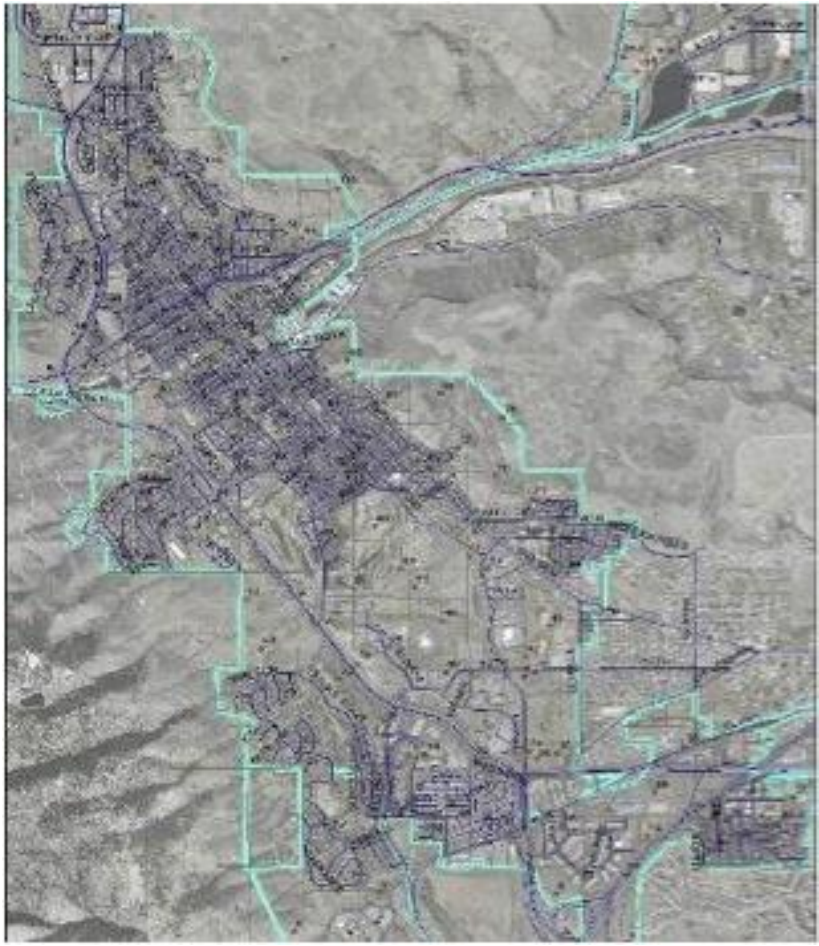
URBAN FORESTRY ANALYSIS

- Evaluated economic value of environmental services
- Determined:
  - Carbon sequestration
  - Air quality impacts
  - Energy impacts
  - Water conservation
  - Stormwater management
- Focused on integration of benefits, tradeoffs



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QUANTIFIABLE IMPACTS OF URBAN FORESTRY

Annual values from Golden, CO (~10,000 public trees, 100,000 total):

- Over $50,000 in stormwater management costs avoided
- Approximately $23 per house in energy savings
- $43,000 of particulate air pollution removal
- ~9 metric tons net ozone air pollution formation

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AIR QUALITY TRADEOFFS

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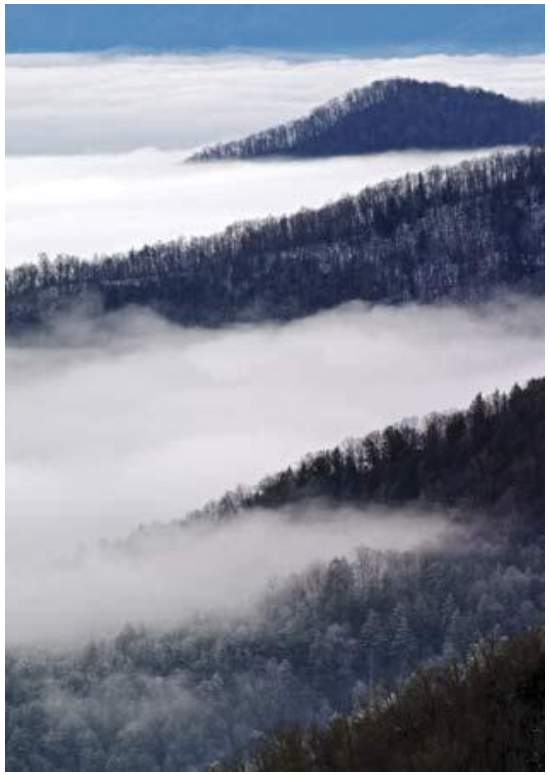
- Temperature moderation
- Air pollution removal
- Summer power plant emissions reduction



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- Winter heating emissions increase
- Maintenance emissions
- Biogenic volatile organic compounds (BVOC) emissions

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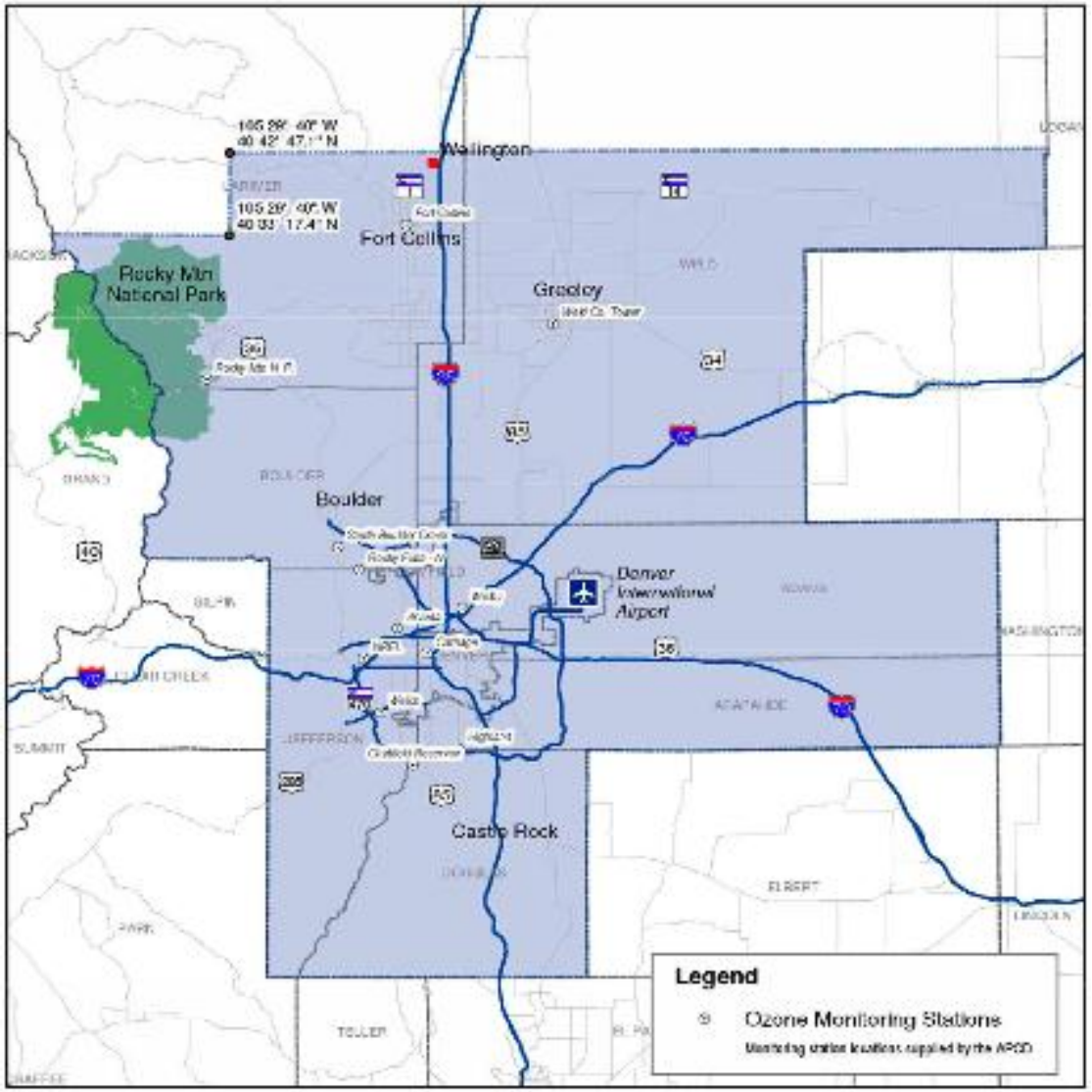
COLORADO'S OZONE CHALLENGE

- Federal 8-hour ozone standard introduced in 1997 (in addition to 1-hour standard)
- Early Action Compact for Ozone signed in 2002 (nonattainment designation deferred)
- Denver Metro Area and North Front Range designated nonattainment under the 1997 standard in 2007
- 8-hour standard made more stringent in 2008



Denver-Boulder-Greeley-Fort Collins Eight-Hour Ozone Control Area

www.cdphe.state.co.us/ap/images/ozoneareamap.gif

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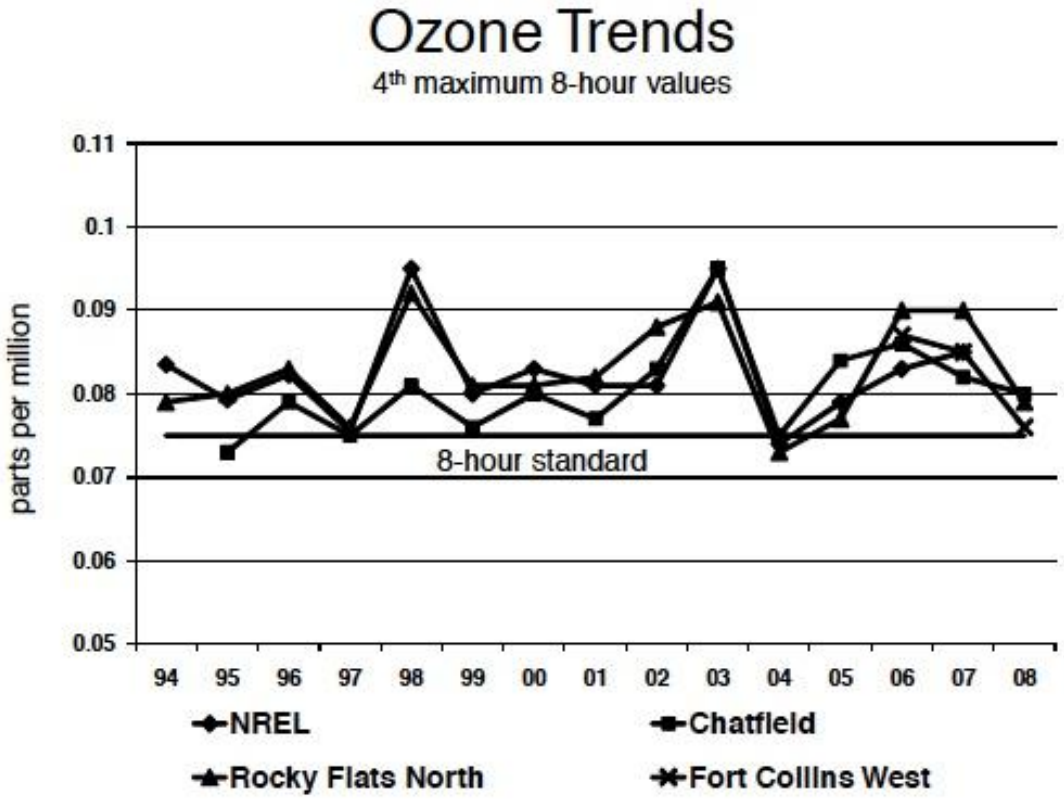
OZONE TRENDS 2004 – 2008

- Ozone level short term trend largely determined by meteorology
- Long term trend, determined by precursor emissions, difficult to see
- Ozone Action Plan targets oil and gas industry and mobile sources of VOCs
- No current strategies deal with biogenic sources of VOC



Source: Air Quality Control Commission Report to the Public 2008-09

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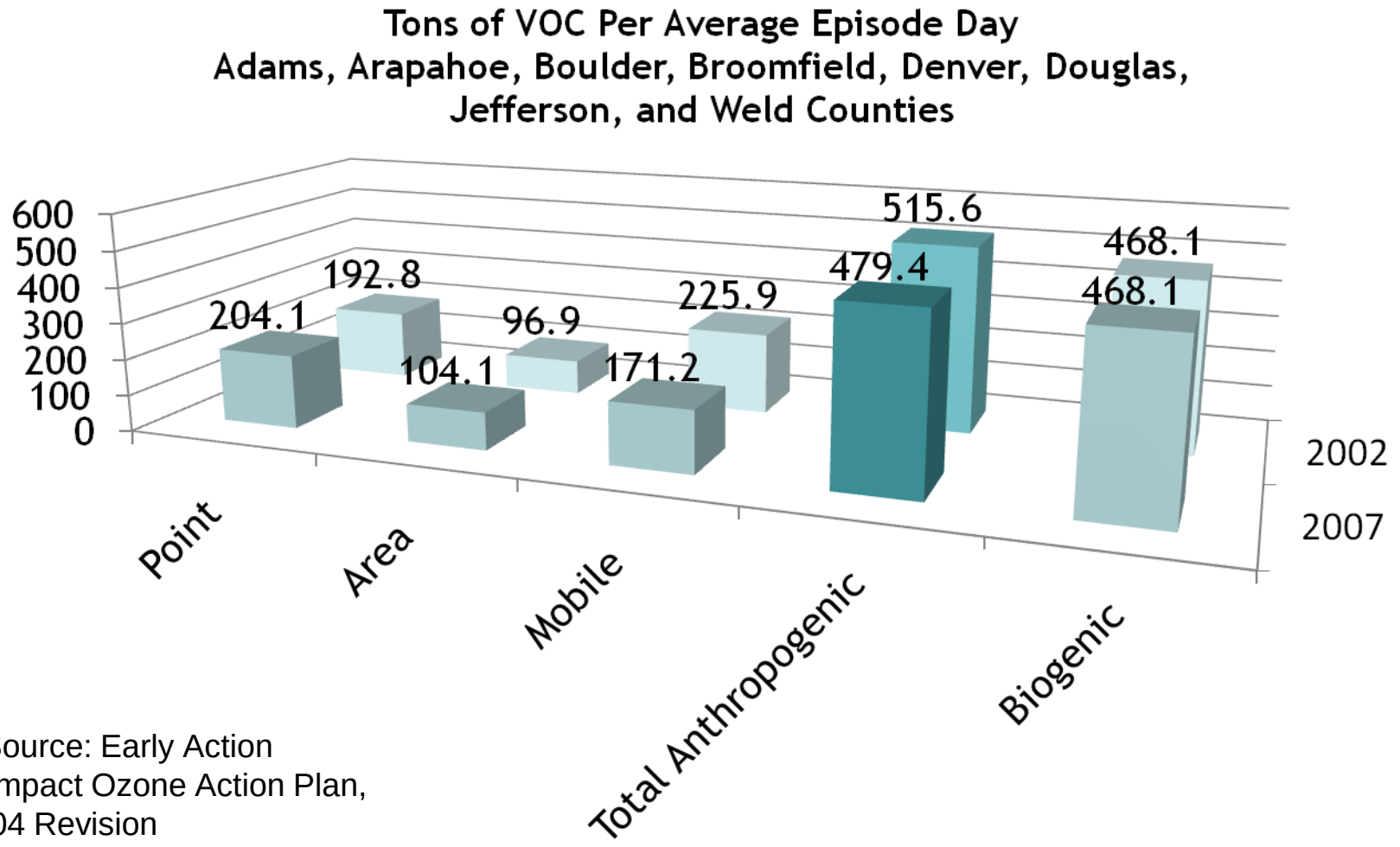
2002 AND 2007 BASE CASE VOC EMISSION INVENTORIES



*Data Source: Early Action Compact Ozone Action Plan, 2004 Revision

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FORESTS AND OZONE AIR POLLUTION

- BVOC emissions (increased ozone formation)
  - Right Tree vs. Wrong Tree – Ozone forming potential of BVOC tree emissions can vary by as much as 5 orders of magnitude
- Ozone destruction
  - Trees ingest ozone through their stomata
  - Trees undergo leaf damage from ozone, which reduces ozone concentrations
- Temperature moderation (reduced formation)
  - Trees lower the ambient temperatures, thus preventing ozone from forming

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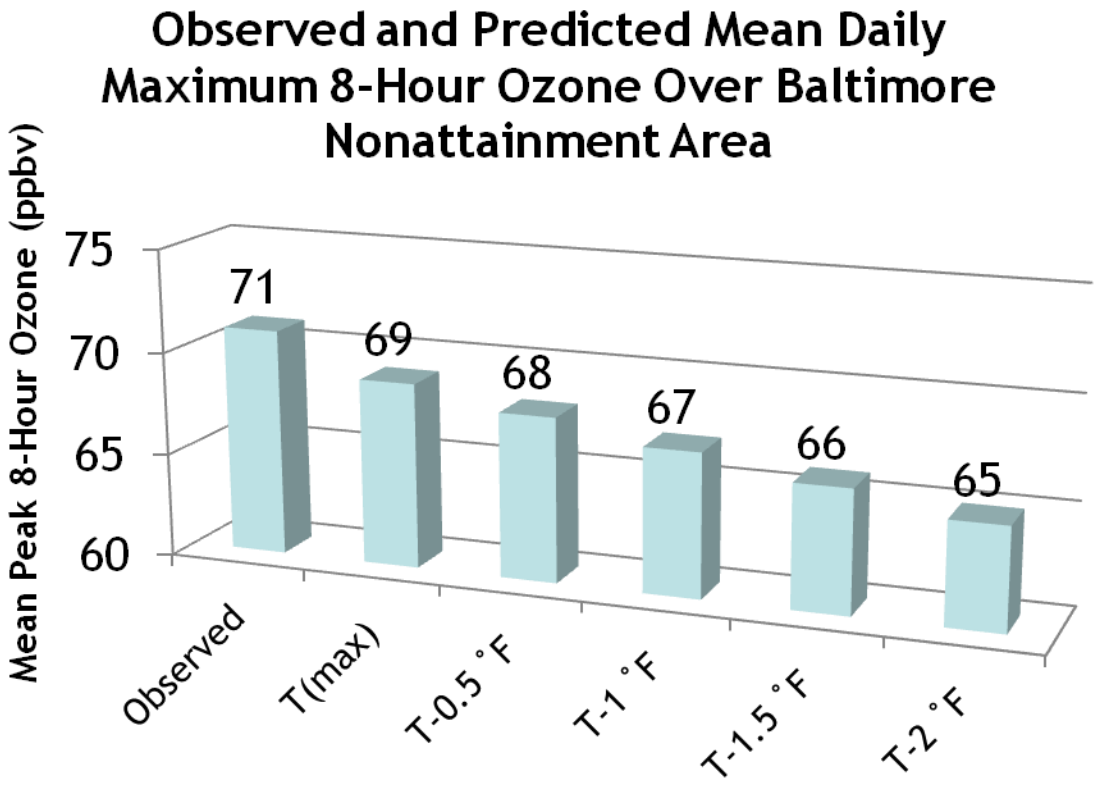
RELATIONSHIP AMONG URBAN TREES, TEMPERATURE, AND OZONE

- Air temperature moderation most significant impact of urban trees on ozone
- With strategic species selection, an increase of 1% in urban tree canopy can result in a decrease in air temperature from 0.04 to 0.2 ˚C (Anyanwu 2006)
- Piety (2007) used regression analysis of daily ozone levels and meteorological variables to predict the reductions shown in the chart at right



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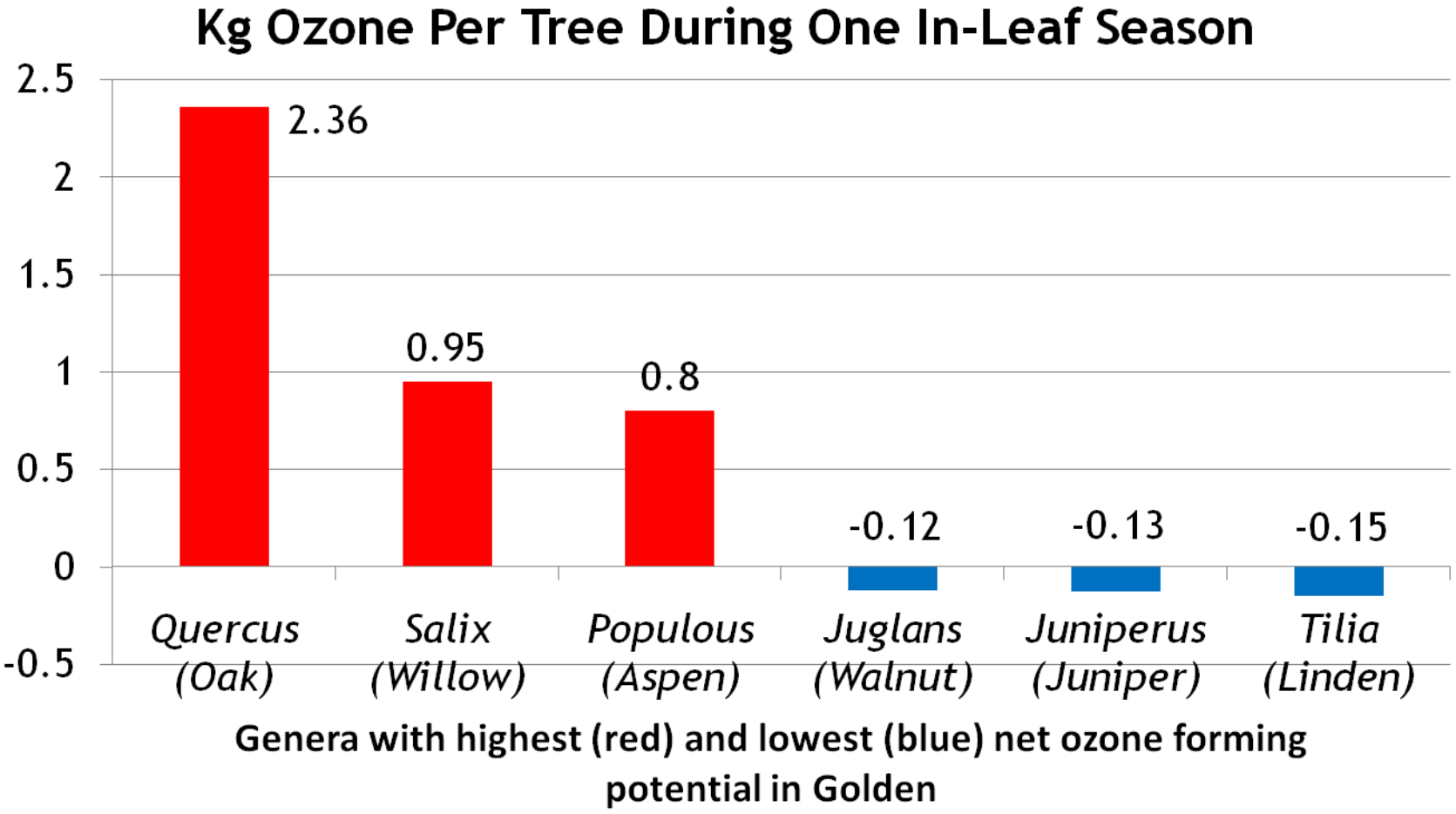
ESTIMATED NET OZONE FORMATION DUE TO URBAN TREES IN GOLDEN, CO



IES Tree Project Phase 2 Final Report

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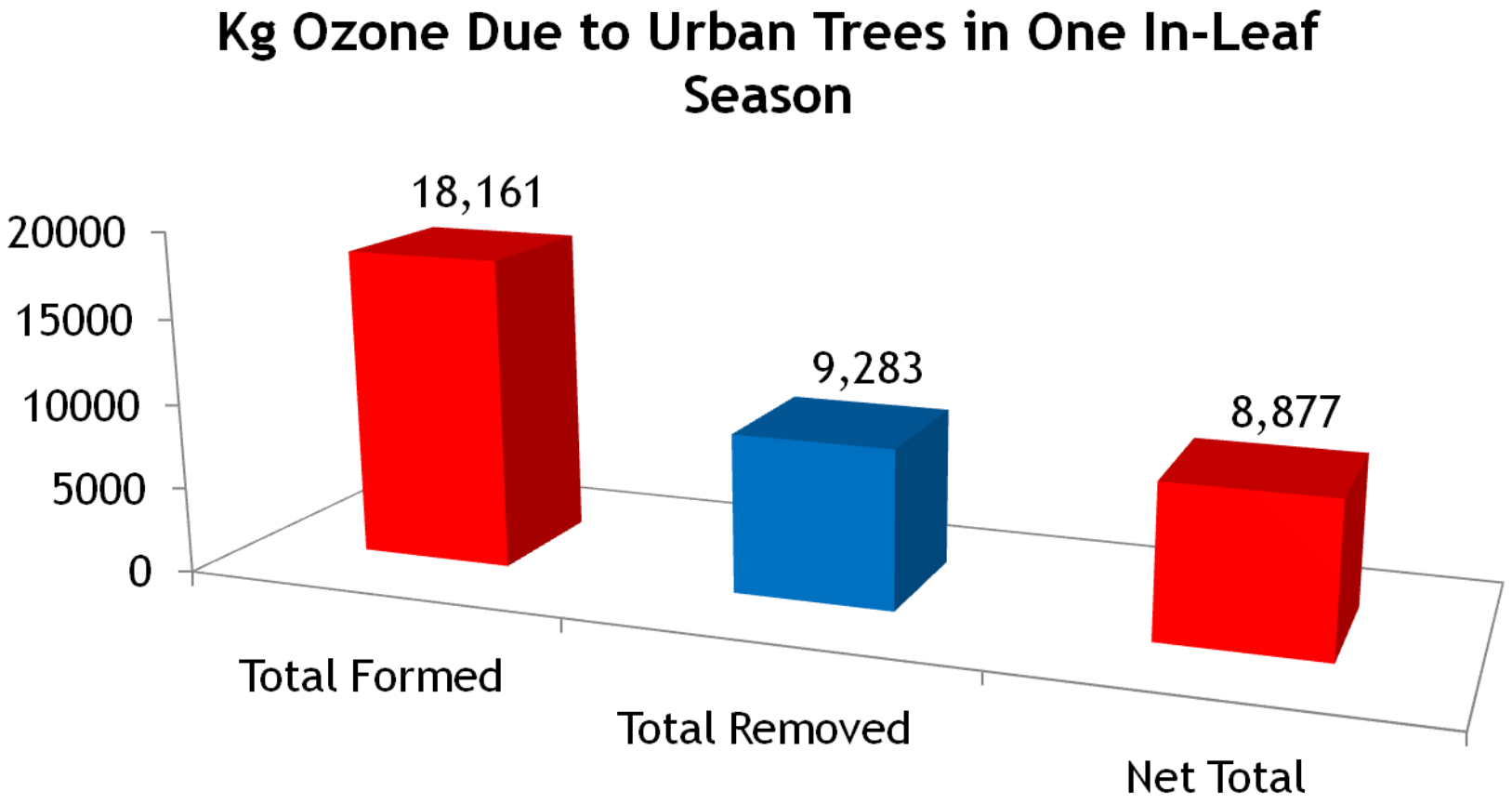
TOTAL ANNUAL OZONE FORMATION DUE TO URBAN TREES IN GOLDEN, CO



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REVIEW OF MODELED AND MEASURED IMPACTS

- Reduction in tree cover of 20% can increase maximum peak 1-hour ozone concentrations by ~14% (Cardelino and Chameides, 1990).
- Temperature reductions on the order of ~1-2˚ C from 40% increase in urban tree cover could lead to a 2-4 ppbv decrease in peak 8-hour ozone levels (Nowak et al., 2000, Civerolo et al., 2000).
- With 40% increase in canopy, major decreases in ozone can occur near urban areas where the 8-hour ozone NAAQS is not met (average 1 ppbv, peak 2.4 ppbv), while the minor increases in ozone occur in upwind areas where the NAAQS is met. The net impact is favorable in terms of entire regions meeting the NAAQS (Nowak et al., 2000, Civerolo et al., 2000).
- Regions with different land use and topography will have different relative biogenic and anthropogenic precursor emissions and therefore will likely require different tree planting strategies (Piety, 2007).

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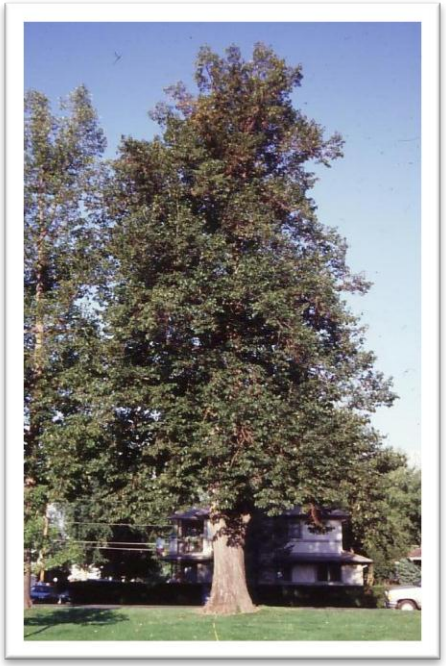
POLICY IMPLICATIONS

- Strategic forestry can contribute to multiple environmental improvement objectives – energy conservation, water conservation, stormwater management, carbon sequestration, criteria air pollution reduction… and ozone control
- Need to understand more about potential impacts of strategic forestry on ozone and other issues
  - How would Front Range meteorology and land use interact with reduced VOC emissions and moderated air temperature due to increased tree canopy?
  - How do we balance investment of water and other resources in forestry with positive ozone impacts?



Littleleaf Linden

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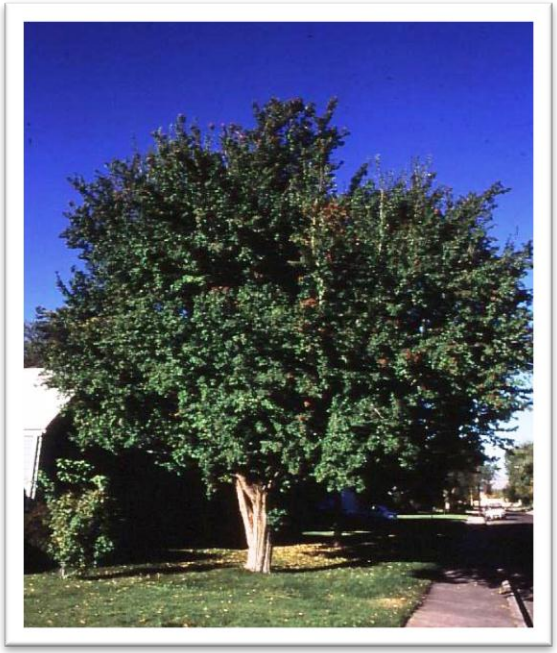
CONCLUSION



Hawthorn

- Strategic forestry should be considered as part of the solution to ozone air pollution
- The interaction of increased tree canopy and meteorology as well as comparative costs and benefits of strategic forestry for ozone mitigation need to be investigated
- The urban forest returns multiple environmental benefits, of which ozone mitigation is one
- Local governments, property owners, tree professionals should consider environmental impacts of tree selection and planting to optimize benefits

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