Isoprene Emission Rates from Extreme Heat Exposure Due to Climatic Changes on *Quercus* and *Populus* Tree Genera: A Systematic Literature Review

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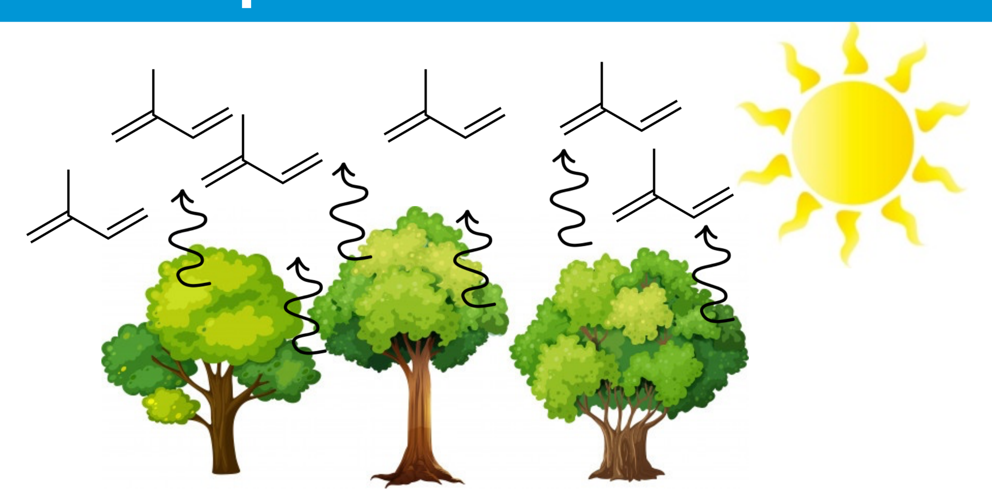
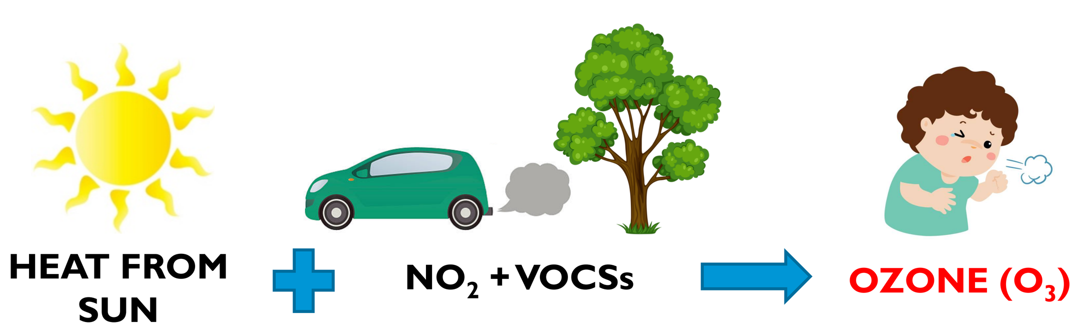
Study Question

Does increased heat lead to changes in isoprene emissions in *Quercus* (oak) and *Populus* (poplar) tree genera?

Scope & Introduction





Isoprene

- Greatest contributor to Volatile Organic Compound (VOC) emissions and is highly reactive
- Plants emit in response to stressors and to communicate
- Forms tropospheric (ground-level) ozone (O_3) in presence of NO_x

Heat

- Air composition of planet changing due to human induced climate change
- Heat may act like a stressor to plants
- Heat projected to have direct implications on gas exchange between plants and atmosphere

Intersection:

- Understand changes in isoprene emissions in urban trees in higher temperatures
- Climate resiliency plans to consider urban heat island effect by increasing canopy cover and shade
- Ozone produced as byproduct – negative health implications including exacerbated asthma attacks, decreased lung function, cardiovascular disease

PECO Statement

Population: *Quercus* and *Populus* trees

Exposure: Heat

Comparator: *Quercus* and *Populus* not exposed to heat

Outcome: Isoprene emission rates

Study Selection Criteria (Methods)

Preliminary Criteria:

- Tree genera: *Quercus* and *Populus*
- Location: United States
- Exposure terms: heat, rising temperature, increasing temperature
- Population terms: tree, trees, oak, quercus, poplar, populus
- Outcome terms: isoprene, VOC, volatile organic compound, biogenic isoprene
- Databases searched: Scopus, Web of Science, and ProQuest Environmental Science Collection

Methods

Study Selection using the Navigation Guide

- N = 402 — Records identified through database searching
- N = 0 — Records identified through other sources
- N = 309 — Records screened by title and abstract
- N = 93 — Duplicates removed
- N = 282 — Records excluded
- N = 9 — Full-text articles assessed for eligibility
- N = 18 — Full-text articles excluded
- N = 9 — Studies included in qualitative analysis

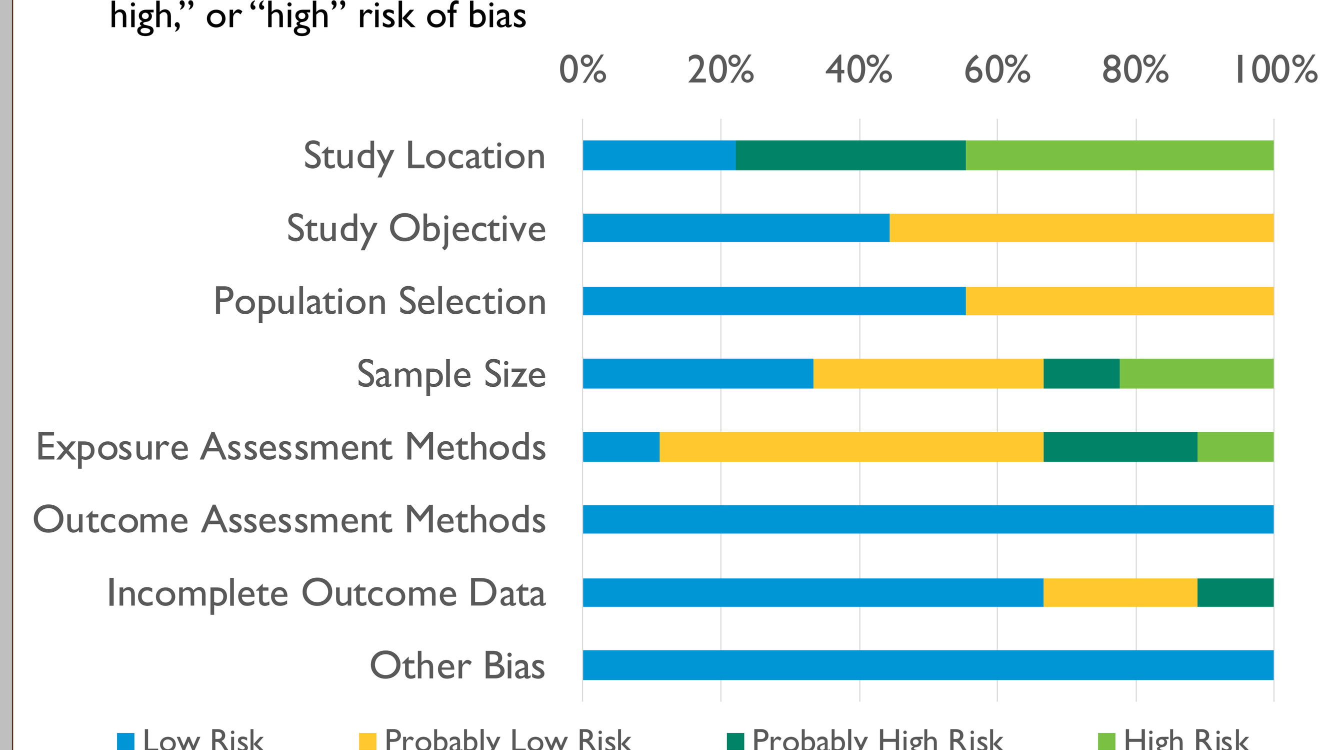
Results

Overview of studies included in qualitative analysis

Study	*Copolovici* 2015	*Fares* 2010	*Fortunati* 2008	*Funk* 2004	*Jud* 2016	*Lahr* 2015	*Sharkey* 1996	*Tingey* 1979	*Vanzo* 2015
Study Population	*Quercus rubra* 2-yr-old seedlings	*Populus x euramericana* 1-yr-old	*Populus nigra* 1-yr-old saplings	*Populus deltoides* 2-yr-old	*Populus x canescens* 4 plant genotypes: 2 isoprene-emitting lines and 2 non-isoprene-emitting lines	*Quercus stellate* and *Liquidambar styraciflua*	*Quercus alba* and *Quercus rubra*	*Quercus virginiana* Seedlings	*Populus canescens* 4 plant genotypes: 2 isoprene-emitting lines and 2 non-isoprene-emitting lines
Location	Greenhouse	Growth chambers	Growth chambers	Greenhouse	Grown in greenhouse then moved to Phytotron Chamber	Texas-Houston (urban), The Woodlands (suburban), Sam Houston National Forest (rural)	Duke University Research Forest	Cultured in greenhouse, then moved to growth chamber	Grown in greenhouse then moved to Phytotron Chamber
Sample Type	Leaf	Leaf	Leaf	Leaf	Leaf	Leaf	Leaf	Leaf	Canopy and leaf

Step 1: Risk of Bias

- Utilized Navigation Guide to evaluate the Risk of Bias for each study
- "Risk of Bias" domains: study location, study objective, population selection, sample size, exposure assessment methods, outcome assessment methods, incomplete outcome data, and other bias
- Possible ratings for each domain were "low," "probably low," "probably high," or "high" risk of bias



Step 2: Quality of Evidence

- Utilized Navigation Guide to rate quality of evidence as *high*, *moderate*, or *low*
- Parameters of consideration:
  - Downgrading: Risk of bias; Indirectness; Inconsistency; Imprecision; Publication bias
  - Upgrading: Large magnitude of effect; Dose response; Confounding minimizes effect
- Overall quality of evidence was rated as being **moderate**

Step 3: Strength of Evidence

- Utilized Navigation Guide considerations when determining the strength of evidence:
  - Quality of body of evidence
  - Direction of effect estimate
  - Confidence in effect estimate
  - Other compelling attributes
- Overall strength of evidence was rated as being **limited**

Discussion/Conclusion

- Overall, the quality of evidence presented in the literature review was **moderate**
- The strength of evidence presented amongst the included studies is **limited**
- There may be an association between rates of isoprene emission and heat exposure on *Quercus* and *Populus* tree genera
- Mitigating or reversing rising global temperatures could reduce rates of isoprene emissions → reducing health risks of O_3 exposure
- Anthropogenic sources of NO_x should be reduced to disrupt oxidation process
  - Replace traditional combustion engines with methods of transportation that use clean, renewable sources of energy
- **Study Strengths:**
  - Consistency in outcomes across majority of studies
  - Exposure to heat in controlled environment
- **Study Limitations:**
  - Unknown how trees would react in natural world setting
  - Two studies measured entire tree canopy – rest only measured single leaf emission rates

Next Steps

Are there other factors influencing isoprene emissions?

- Humidity?
- Sunlight?
- Soil conditions?

Modeling?

- Determine the net impact of carbon sequestration coupled with isoprene emissions
- Physiological responses of trees to climate change and biosphere-atmosphere interactions

References

Papers included in the study:

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