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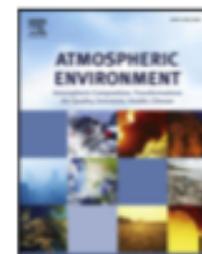
**Environmental Sciences &  
Engineering Department**



Contents lists available at ScienceDirect

## Atmospheric Environment

journal homepage: [www.elsevier.com/locate/atmosenv](http://www.elsevier.com/locate/atmosenv)



### Leaf enclosure measurements for determining volatile organic compound emission capacity from *Cannabis spp.*



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**ENVIRONMENTAL**  
Science & Technology

Viewpoint

[pubs.acs.org/est](https://pubs.acs.org/est)

## High Time to Assess the Environmental Impacts of Cannabis Cultivation

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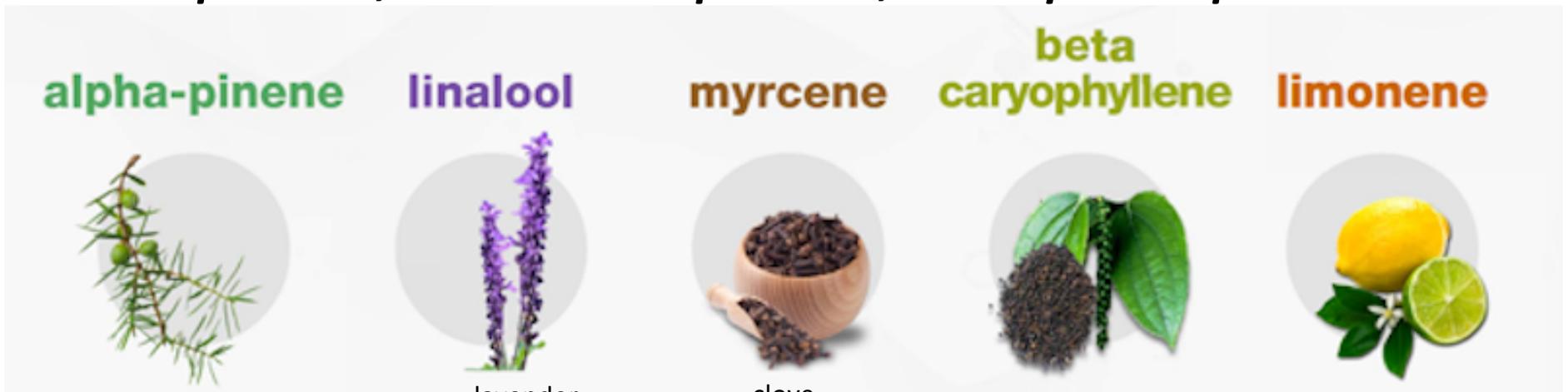
# Volatile Organic Compounds (VOCs)

*Man Made (Anthropogenic)*

Toluene, gasoline, personal products

*Natural Made (Biogenic)*

*Isoprene, Monoterpenes, Sesquiterpenes*



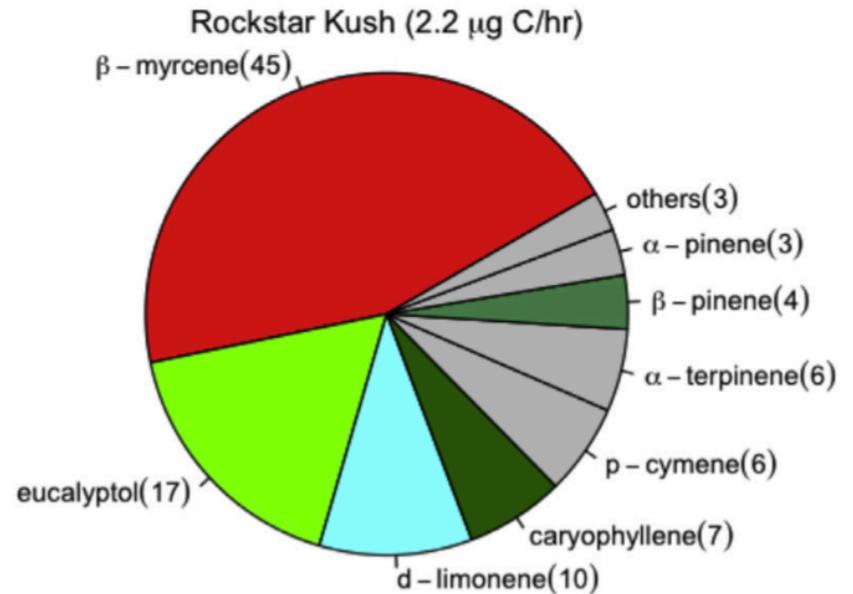
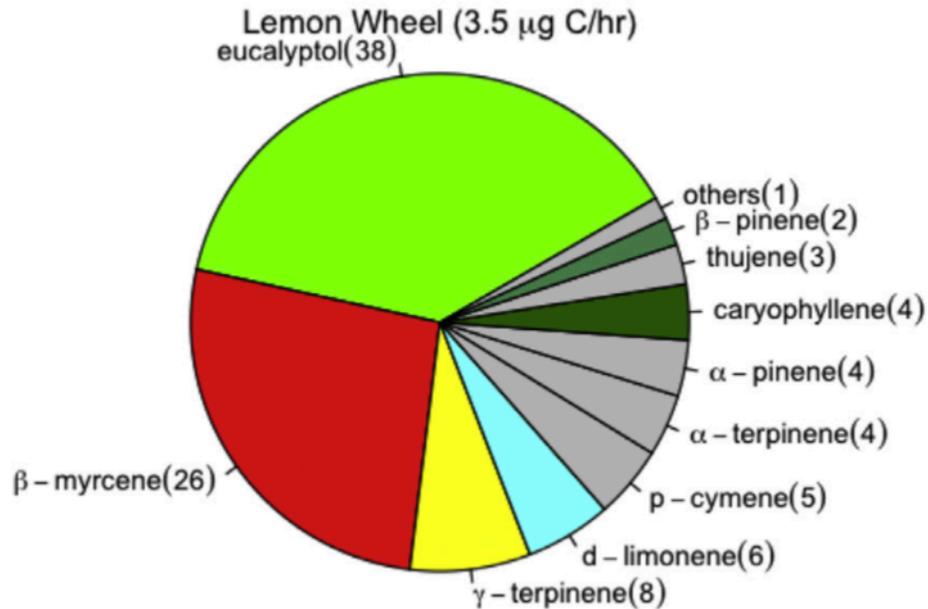
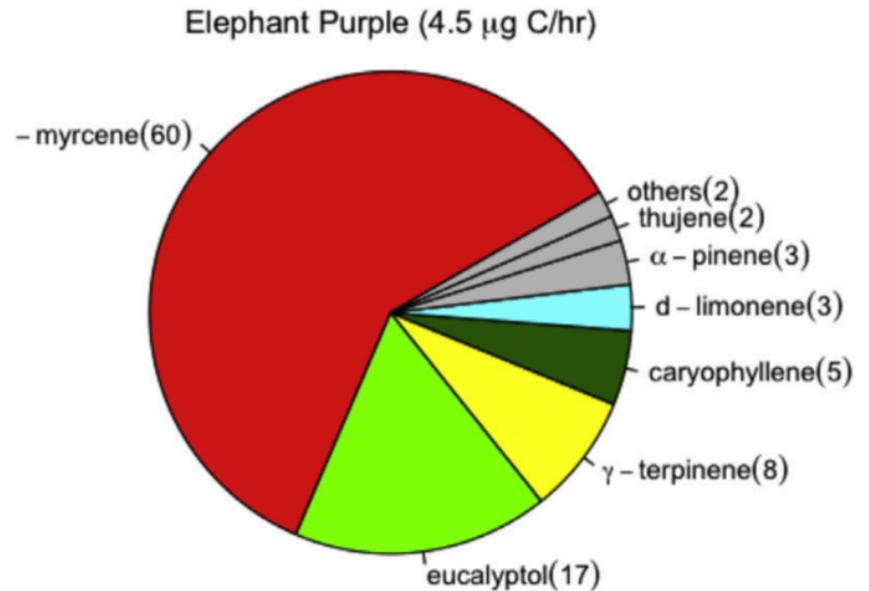
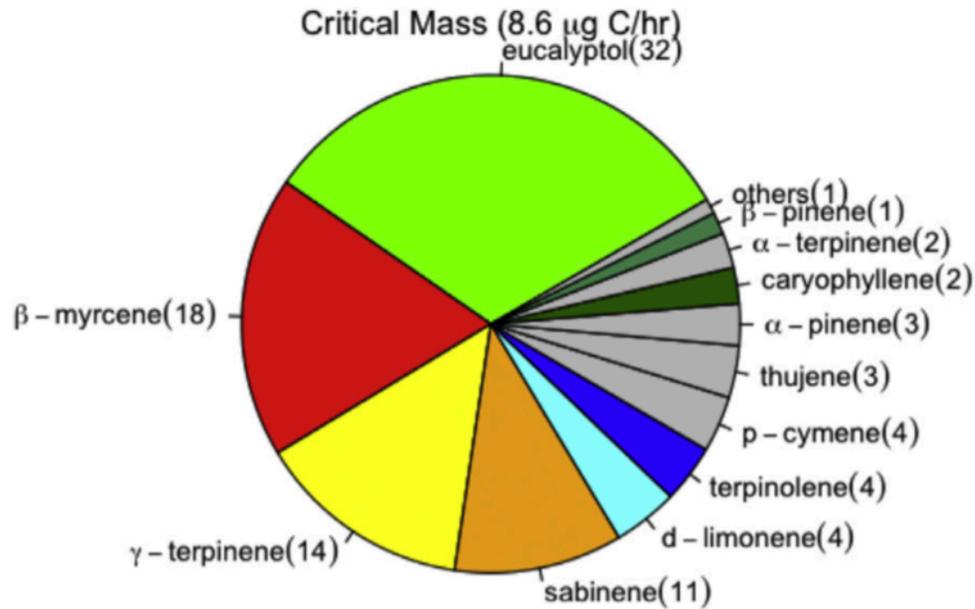
lavender

clove

# VOCs from Marijuana?



# VOCs from Marijuana?

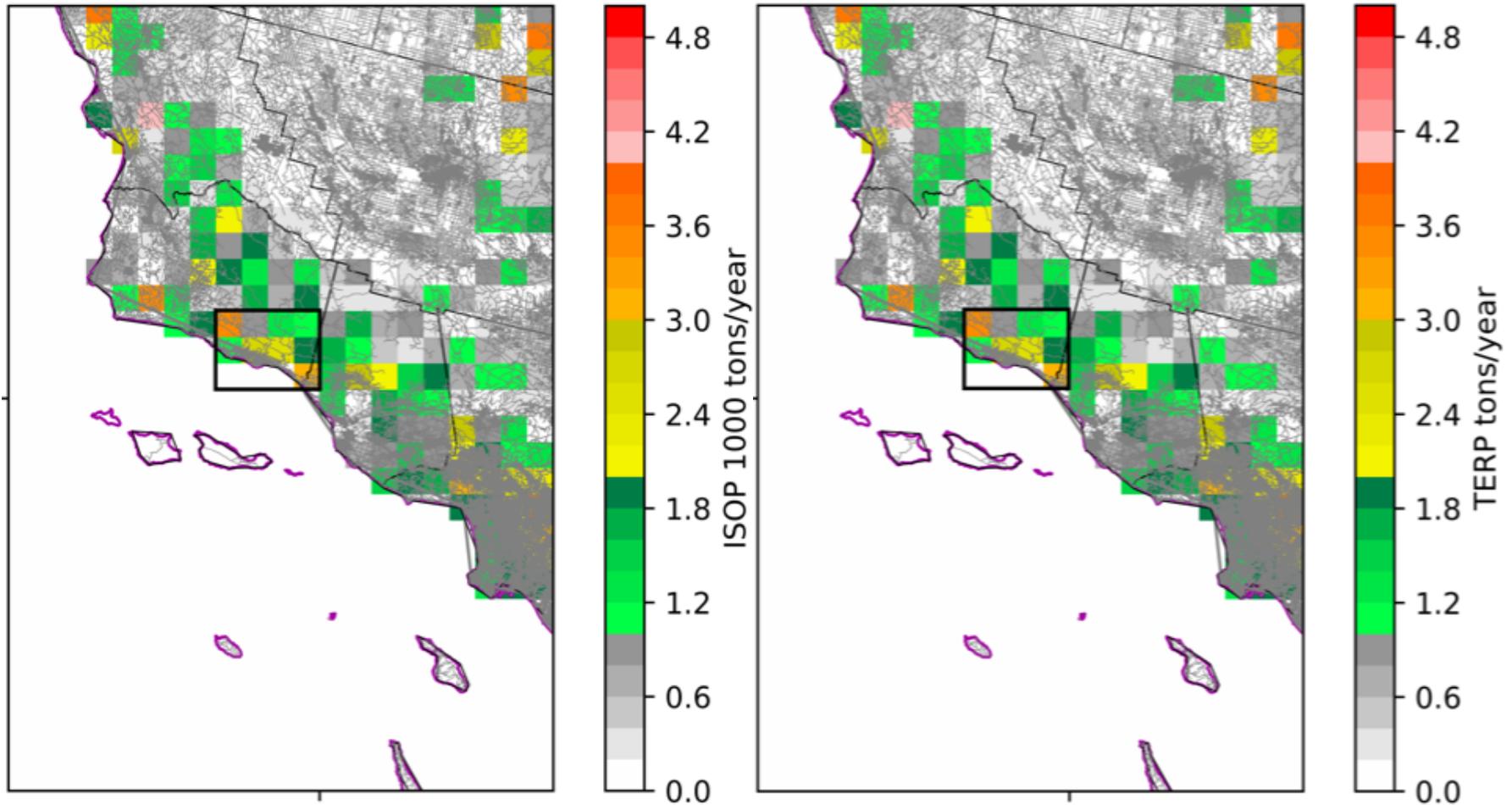


# Monoterpene Emission Rates

- Critical Mass –  $8.6 \mu\text{g C/g/hr}$
- Elephant Purple -  $4.5 \mu\text{g C/g/hr}$
  
- Pine Trees –  $\sim 16 \mu\text{g C/g/hr}$
- Pistachio Trees –  $\sim 8 \mu\text{g C/g/hr}$
- Rosemary –  $\sim 4 \mu\text{g C/g/hr}$

# Monoterpene Emissions

- EPA 2011 Santa Barbara County
- 39,042 tons/year Biogenic VOCs (78% of all VOCs)



# Monoterpene Emissions

- 39,042 tons/year Biogenic VOCs
- Replacing Gerbera Daisy/Tulips are also BVOC emitters
- ~5 tons/year Monoterpenes from Cannabis Industry  
Carpinteria, CA

# Biogenic VOC Exposures

- Model Predicted Concentrations Summer 2011
  - Santa Barbara County .25 ppb (.8 ppb)
  - Denver 0.1 ppb (0.2 ppb)
- Measured downwind Cannabis, Denver CO
  - 0.4 – 0.8 ppb
- Amazon Rain forest – 2-4 ppb isoprene
- Peeling an orange - ~100 ppb Limonene
- Saw Mills – ~50-100 ppm of  $\alpha$ -pinene

# Monoterpene Toxicity

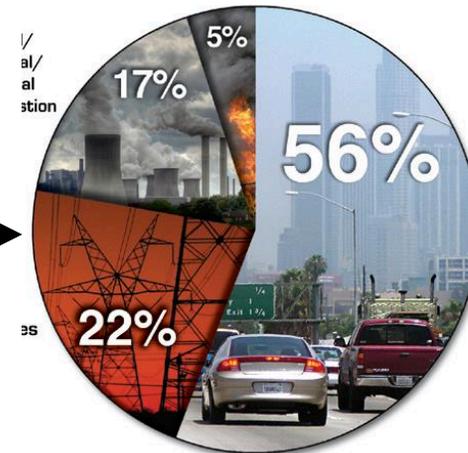
- Most terpenes non-toxic
- Acute short term inhalation (limonene,  $\alpha$ -terpineol, and  $\alpha$ - and  $\beta$ -pinene) is  $\sim 10^6$  ppm ( $59 \text{ mg/m}^3$ )
- 5,000 times higher in ambient terpene hotspots

# VOCs and Ozone/PM

## 1. Sunlight



## 2. NOx



## 3. VOCs

