Smoke Emissions from Prescribed Burning in the Lake Tahoe Basin (Nevada/California)

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Background

- Biomass burning (i.e. prescribed fires, wildfires, residential wood combustion) is an important source of particulate matter (PM) in Lake Tahoe Basin
- Prescribed burning used to manage fuel loads
- Important where wildfires have been suppressed over decades (as in the Lake Tahoe Basin)
- In Lake Tahoe Basin, >1000 acres of landscape underburns and >3000 acres of pile burns done since 1997

Prescribed burning

After burns

Goals

- To reduce PM pollution in the Lake Tahoe Basin, it is necessary to know the contribution from different biomass combustion types
- To address this need, our goal was to try to develop tracers for different wood smoke sources by characterizing emissions from

3 Types of prescribed burns:

Pile burns:

Mainly wooden logs (dry)

Landscape underburns:

Mix of green foliage, branches, surface duff

Mixed pile-underburns

Goals

- For comparison, we also characterized emissions from:

Controlled stove burns:

Wooden logs

Green leaves/branches

Surface duff

Ambient Air Sampling (domestic wood combustion)

- 2010: Peak holiday season (btw. Christmas-New Year), cold, lots of snow, lots of tourists
- 2011: Pre-holiday season, warm, no snow, few tourists

Methods

Sampling:

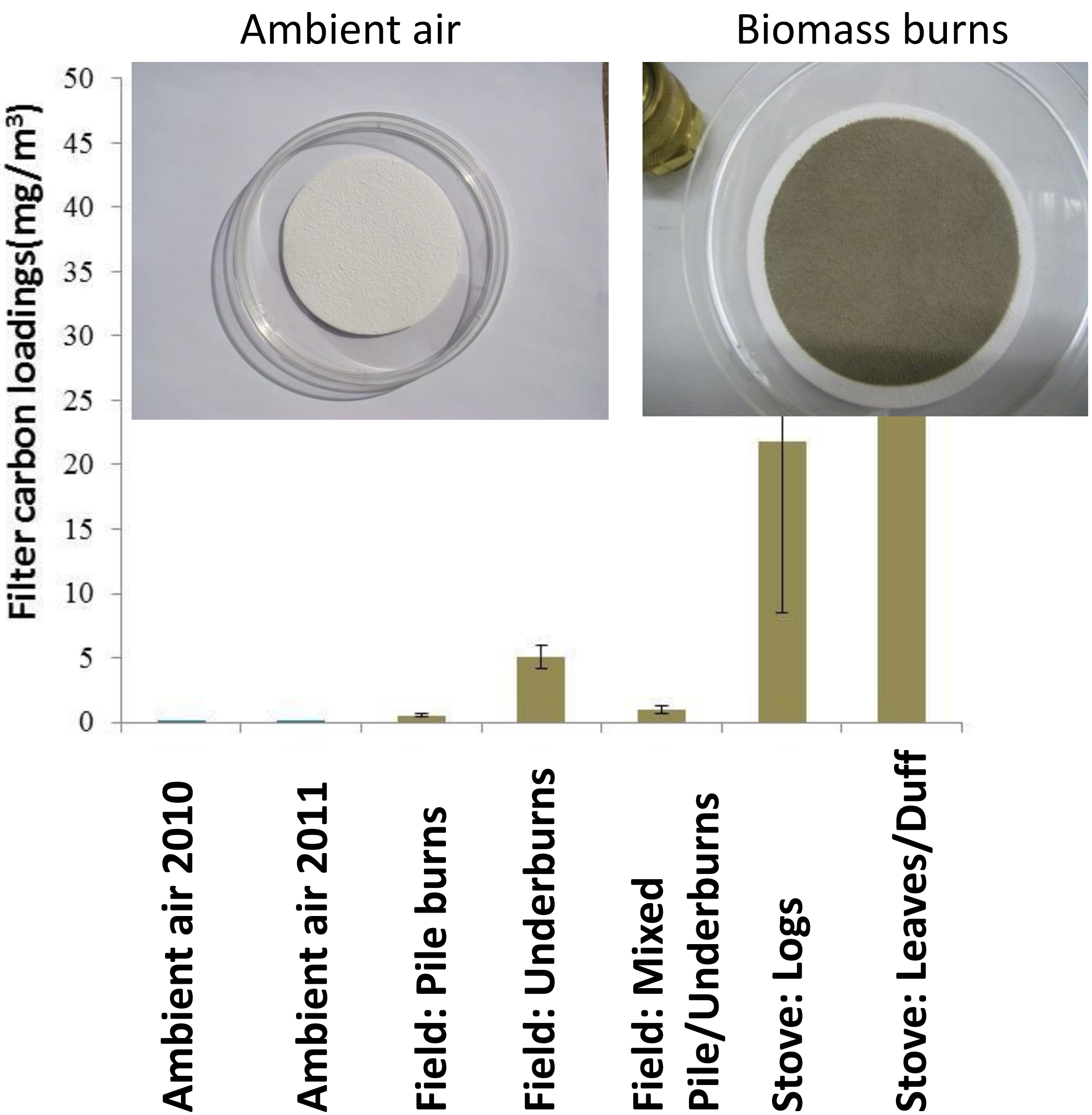
- Medium-volume samplers / quartz filters

Chosen to measure common biomass burning emissions and tracers:

- Organic Carbon (OC) and Elemental Carbon (EC) (IMPROVE_A thermal/optical reflectance protocol)
- 12 polar organic compounds (Varian 4000 GC/MS)

- Water-soluble K^+ (Ion Chromatography)
- Particle-bound Hg (Cold-Vapor Atomic Fluorescence Spectrometry)

Results – Filter C loadings



Burning Emissions:

- High, variable filter loadings

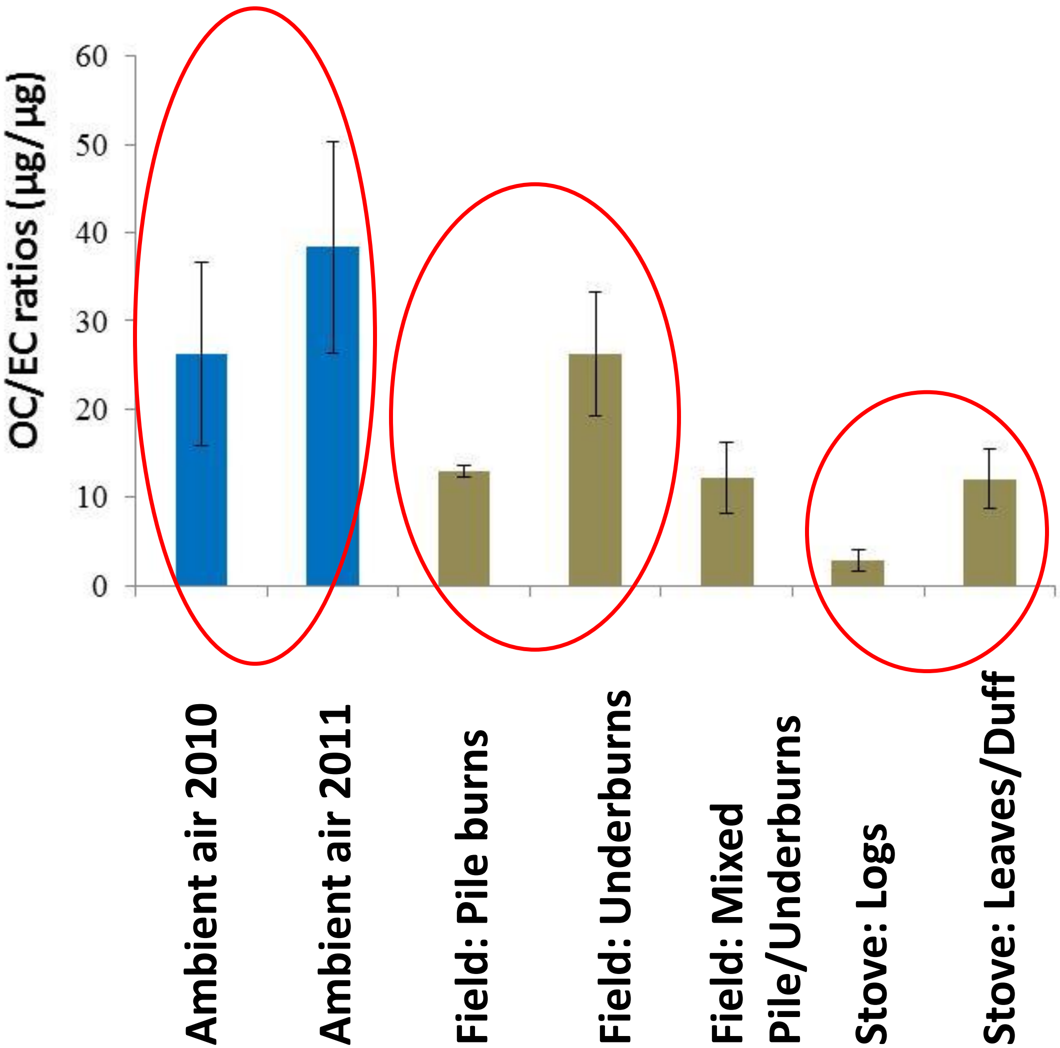
Ambient Air:

- Very low filter loadings

$\Rightarrow$ Need to standardize

(Ratios with Carbon)

Results – OC/EC ratios



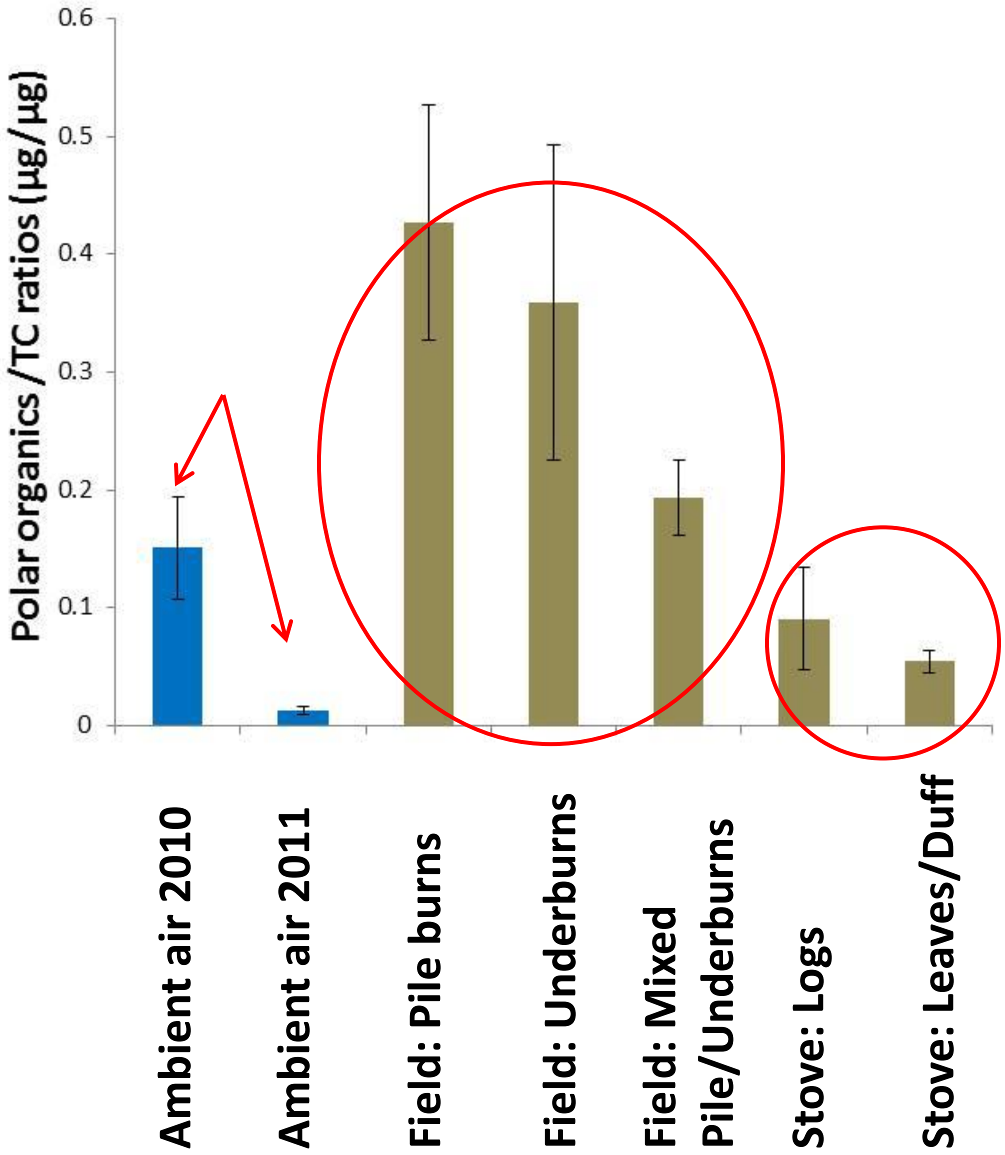
Burning Emissions:

- Field: Underburns > Pile burns
- Stove: Leaves/Duff > Logs
- Likely due to different fire intensities (flaming vs. smoldering combustion)

Ambient Air:

- Not very similar to stove emissions
- Mainly other sources?

Results – Sum of 12 polar organic compounds



Selected 12 polar organic compounds specific to biomass burning

Burning Emissions:

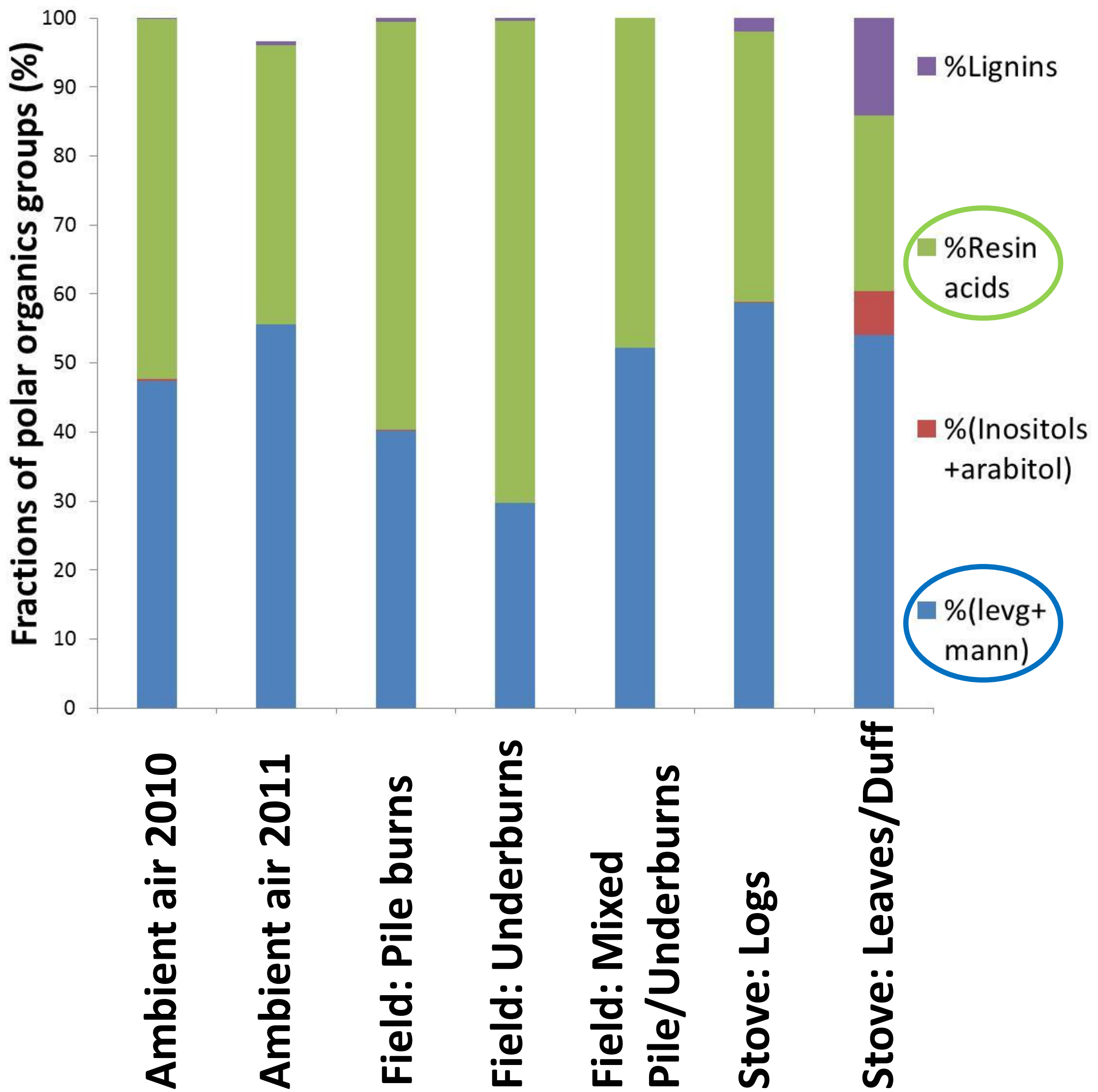
- Field burns > Stove burns
- Trends to higher ratios in logs vs. leaves/duff

Ambient Air:

- Polar organics present in both years
- 2010 > 2011
    - Potentially higher contributions from domestic wood combustion

Results – Groups of polar organic compounds

Emissions results



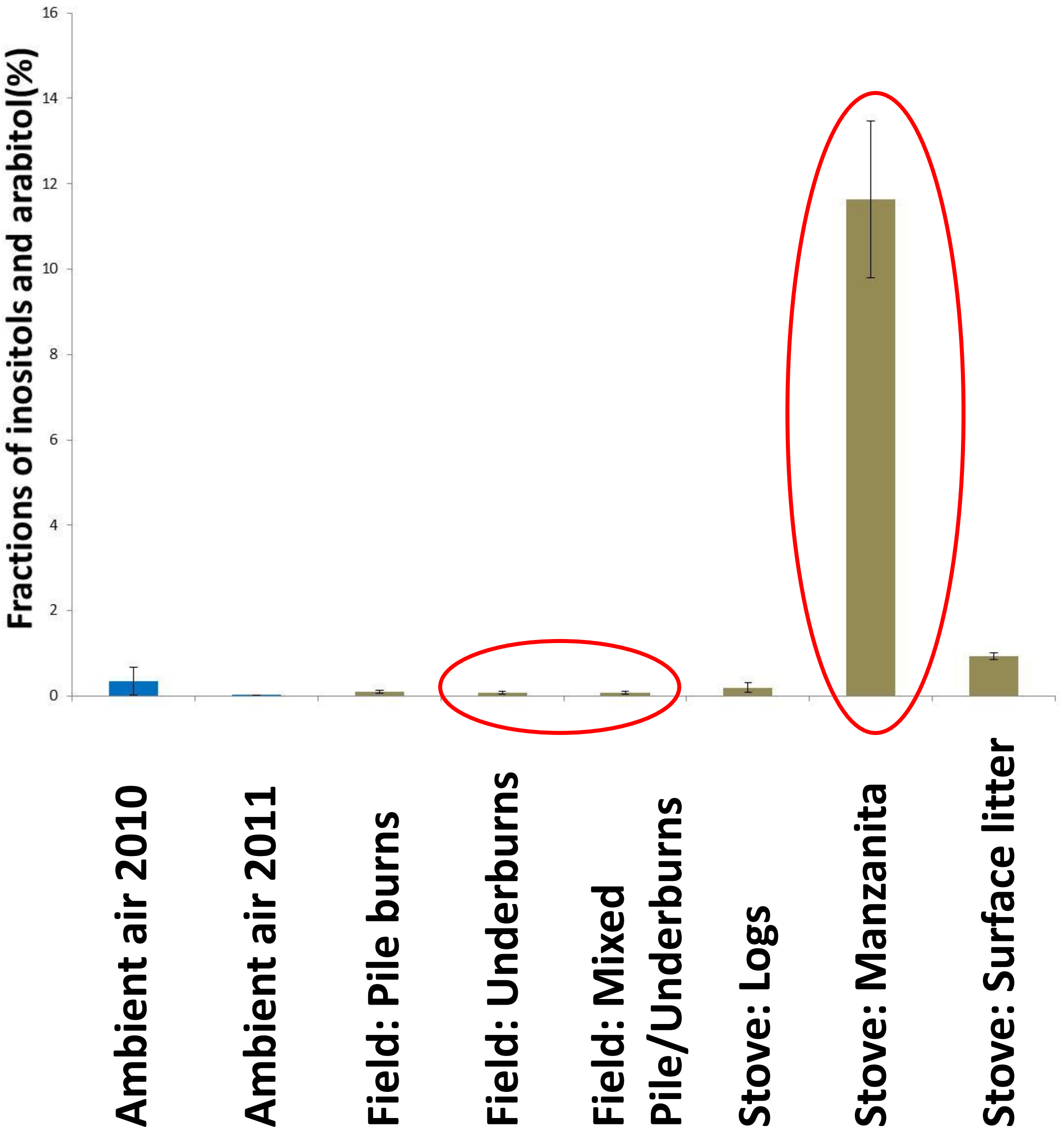
Expected patterns:

- Levoglucosan/mannosan: in dry vegetation
- Inositols/arabitol: in green vegetation
- Resin acids: in coniferous tissue
- Lignins: in green and dry vegetation

But: all emissions dominated by Levoglucosan/Mannosan and Resin Acids

No clear separation btw. different burn types

Results – Inositols and arabitol



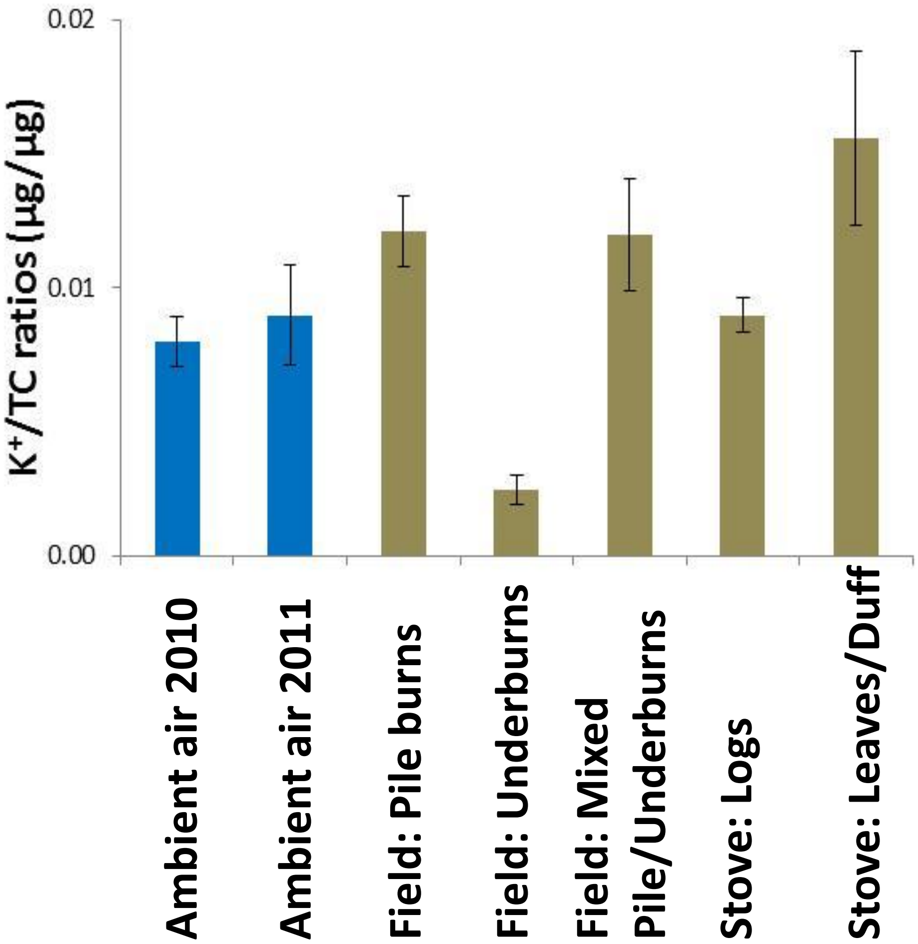
Burning Emissions:

Expected patterns: Inositols/arabitol: in green vegetation

- High in stove burns of *Manzanita* foliage (evergreen understory shrub)
- But: not evident in underburns in field (lots of Manzanita)

$\Rightarrow$ Mass of Manzanita <<wood

Results – Soluble potassium (K^+) to total carbon ratios



Burning Emissions:

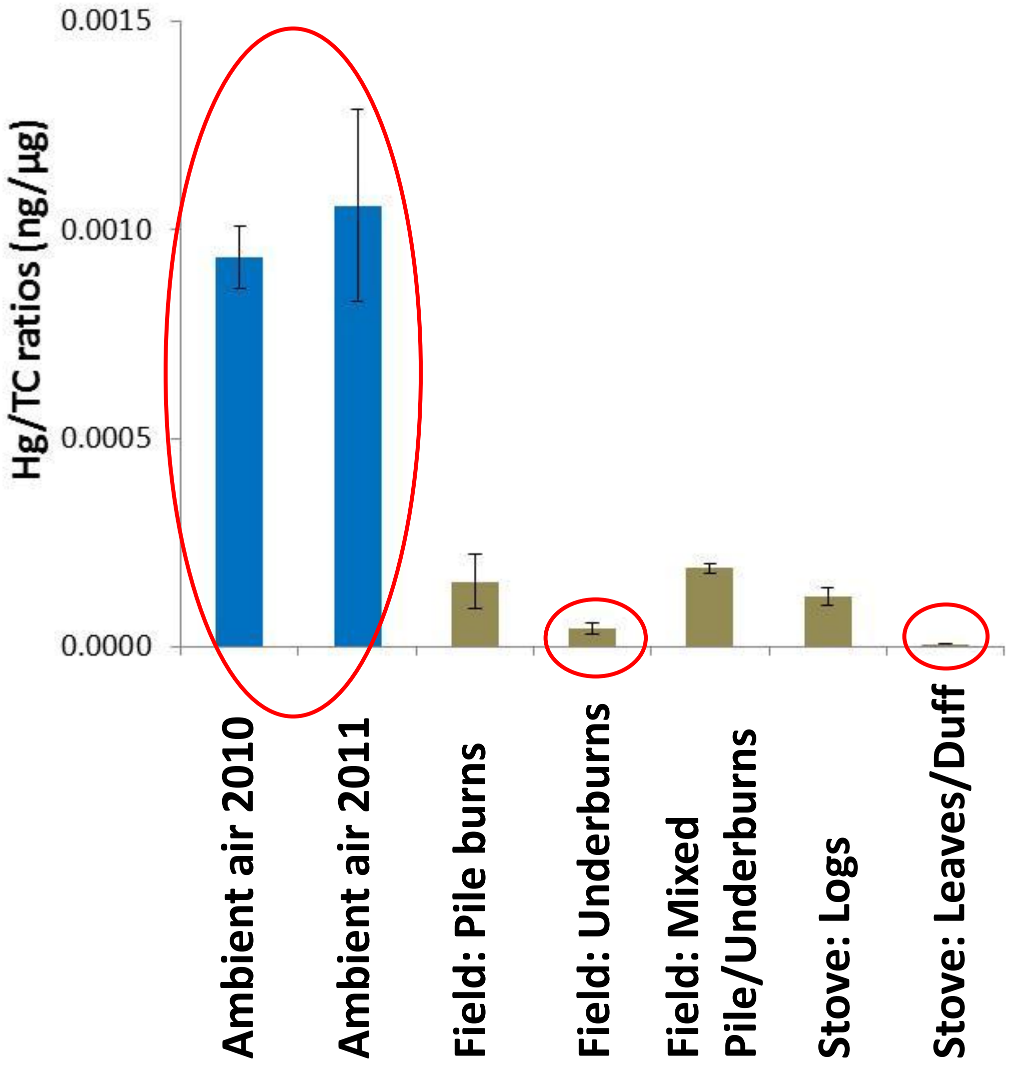
Expected patterns: soluble K^+ good biomass tracer

- Lowest ratios in underburns
- Large overlap between other groups

Ambient Air:

- Similar levels of soluble K^+ as biomass burning emissions
- No different levels between 2010/2011
- Not specific to biomass emissions, other sources?(soil dust, meat cooking...)

Results – Hg to total carbon ratios



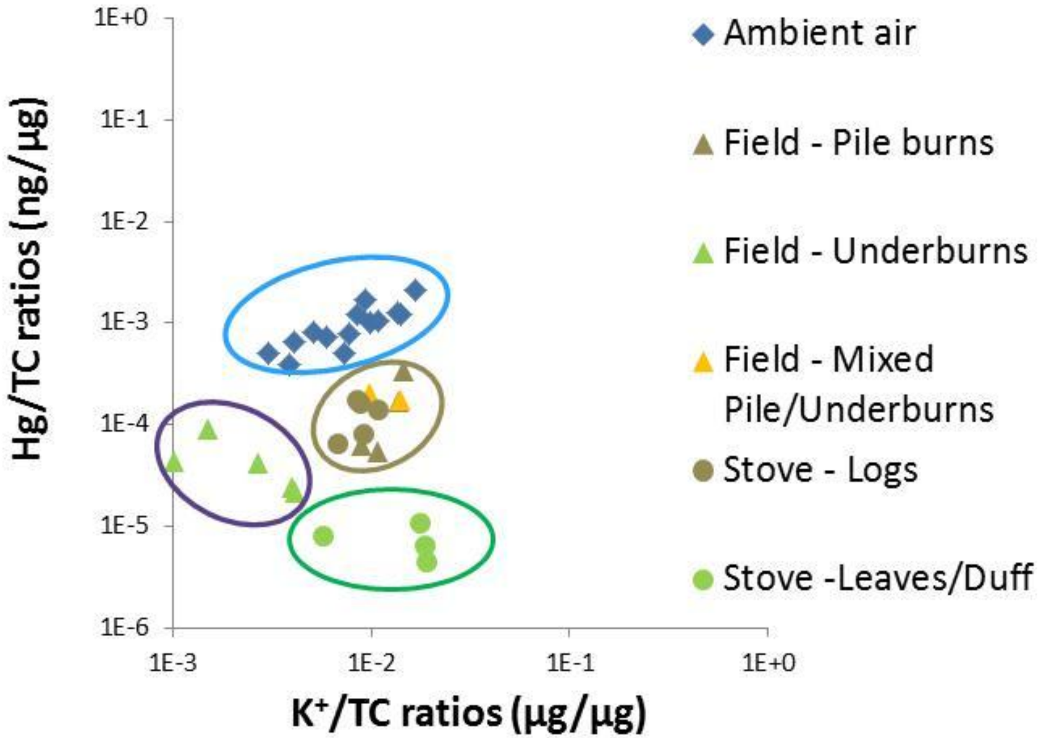
Burning Emissions:

- Lowest Hg ratios in leaves/duff and underburns
- May be useful to differentiate biomass burning types

Ambient Air:

- Much higher Hg/TC ratios in ambient air, likely due to additional Hg sources in residential areas

Hg and K^+ as combined tracers



Burning Emissions:

- Combination of tracers may potentially allow to separate different biomass burning types
- Hg/TC : Ambient air> Wooden biomass /Underburns > Green leaves/duff
- K^+/TC : Leaves/Duff>Underburns

Conclusions

- OC/EC showed higher ratios in green biomass components, indication of smoldering versus flaming emissions
- Polar organic compounds were detectable in all burns and ambient air, dominated by Levoglucosan/Mannosan and Resin Acids
- Inositols and Arobitol significant only in stove burns of green *Manzanita* leaves
- K^+ has lowest ratios in underburns in the field
- Mercury was much higher in ambient air, lowest in green vegetation and underburns emissions

- Using appropriate tracers, it may be possible to separate different burning emissions sources – but it is not easy due to large overlap

Thank you

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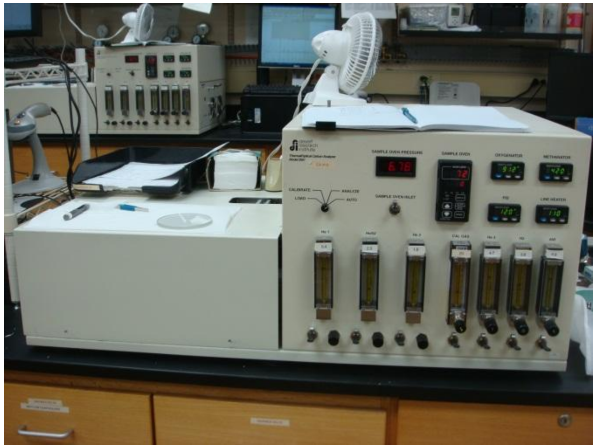
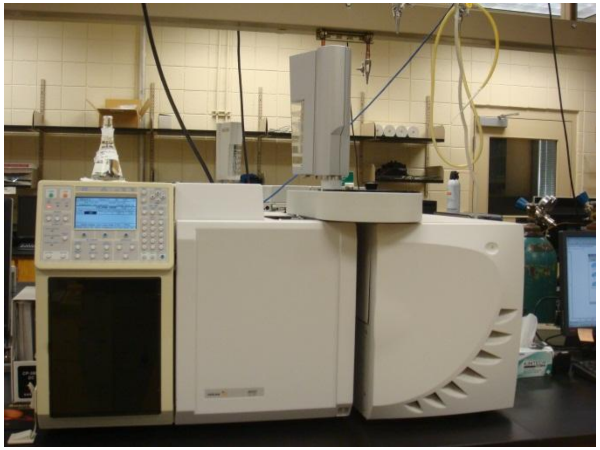
Backup PowerPoint

Lists of 12 polar organic compounds

- Levoglucosan, and mannosan
- Inositols (allo-, myo-, scyllo-) & arabitol
- Resin acids: dehydroabietic acid, pimaric acid, and abietic acid
- lignin derivatives: 4-hydroxybenzoic acid, pyrogallol, and shikimic acid

Methods





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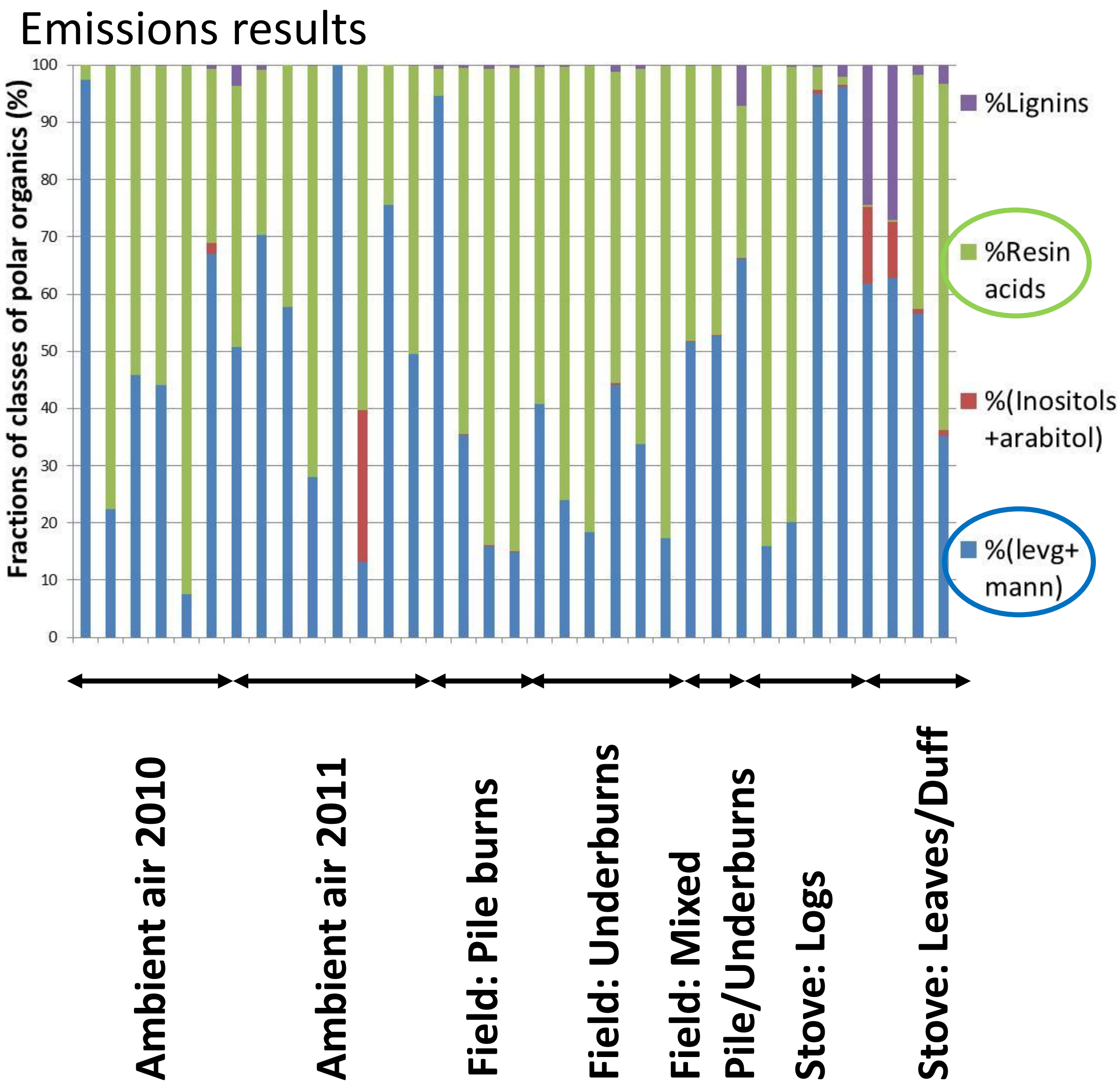
Results – Classes of polar organic compounds



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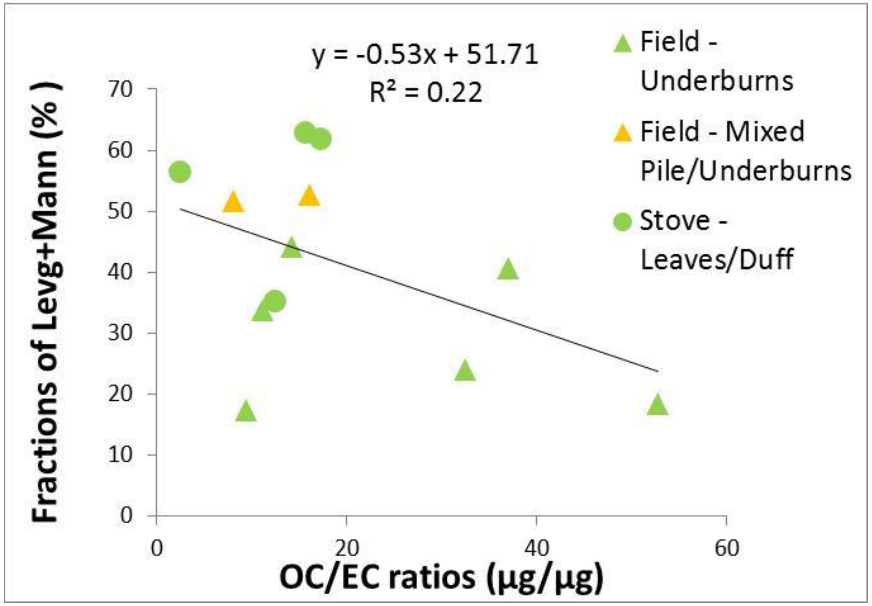
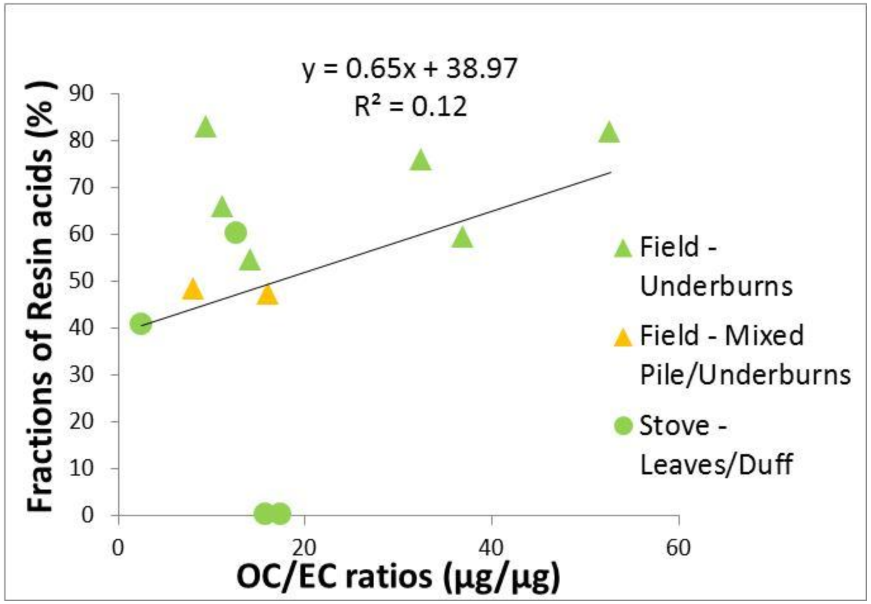
Results- Levoglucosan/mannosan and resin acids



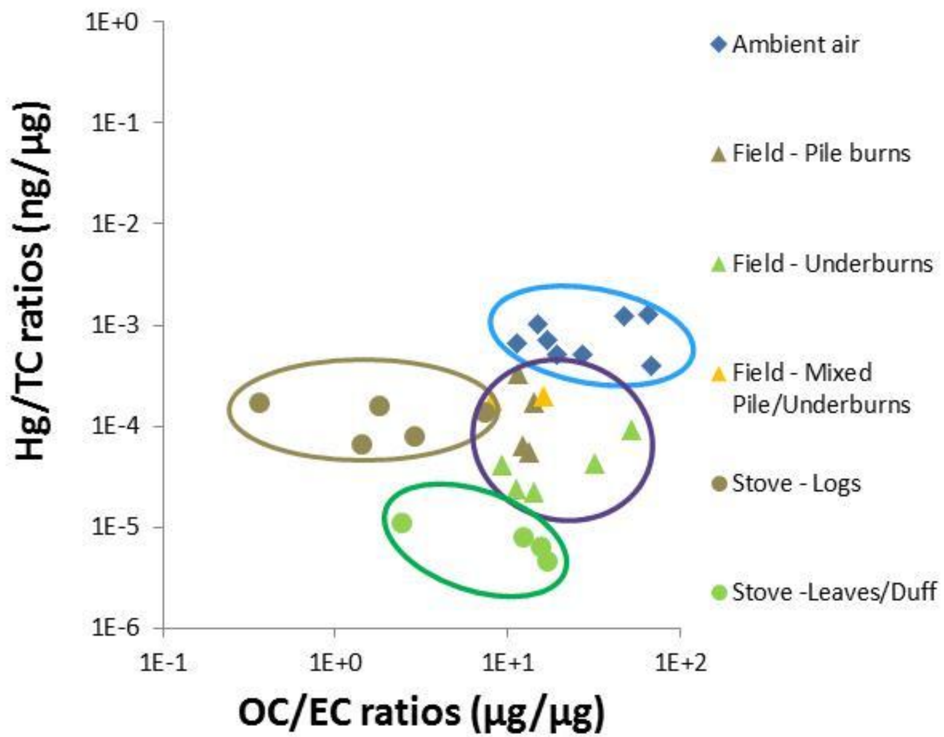


Burning Emissions (no pile):

- % Levoglucosan/mannosan inversely correlated with OC/EC ratios
- % Resin acids positively correlated with OC/EC ratios

Emissions of polar organics may be affected by fire intensity (OC/EC ratio)

Hg and OC/EC as combined tracers



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