



# Smoke Taint: Effect of wildfires on fruit and wine composition

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WASHINGTON STATE UNIVERSITY

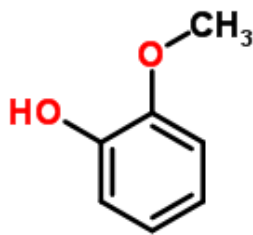
## Smoke taint



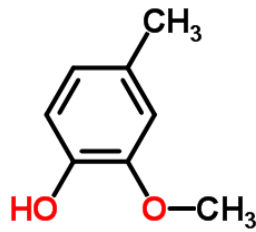
- Wines made from vineyards exposed to smoke from wildfires can develop characteristic aromas and flavors
  - Smokey
  - Ashy
  - Cigar or cigarette smoke
- Strong ashy, cigar-butt aftertaste can also occur
  - In many cases, the aftertaste is more offensive than the aroma
  - Ashy, cigarette smoke notes linger long after the wine is gone.

## First smoke taint research report--2007

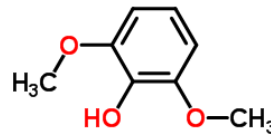
- Kennison, et al, demonstrated that fruit exposed to smoke produced wine which had smoky aromas and flavors
- Guaiacol, 4-methyl guaiacol, 4-ethyl guaiacol, 4-ethyl phenol, eugenol and furfural were identified in wines made with smoked grapes



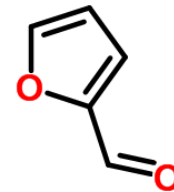
guaiacol



4-methyl guaiacol

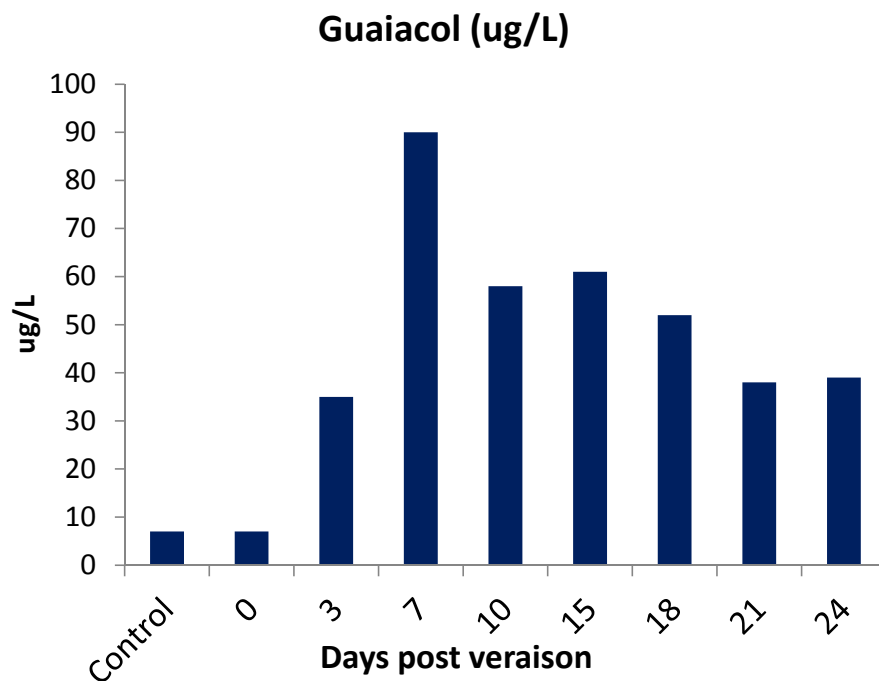


syringol



furfural

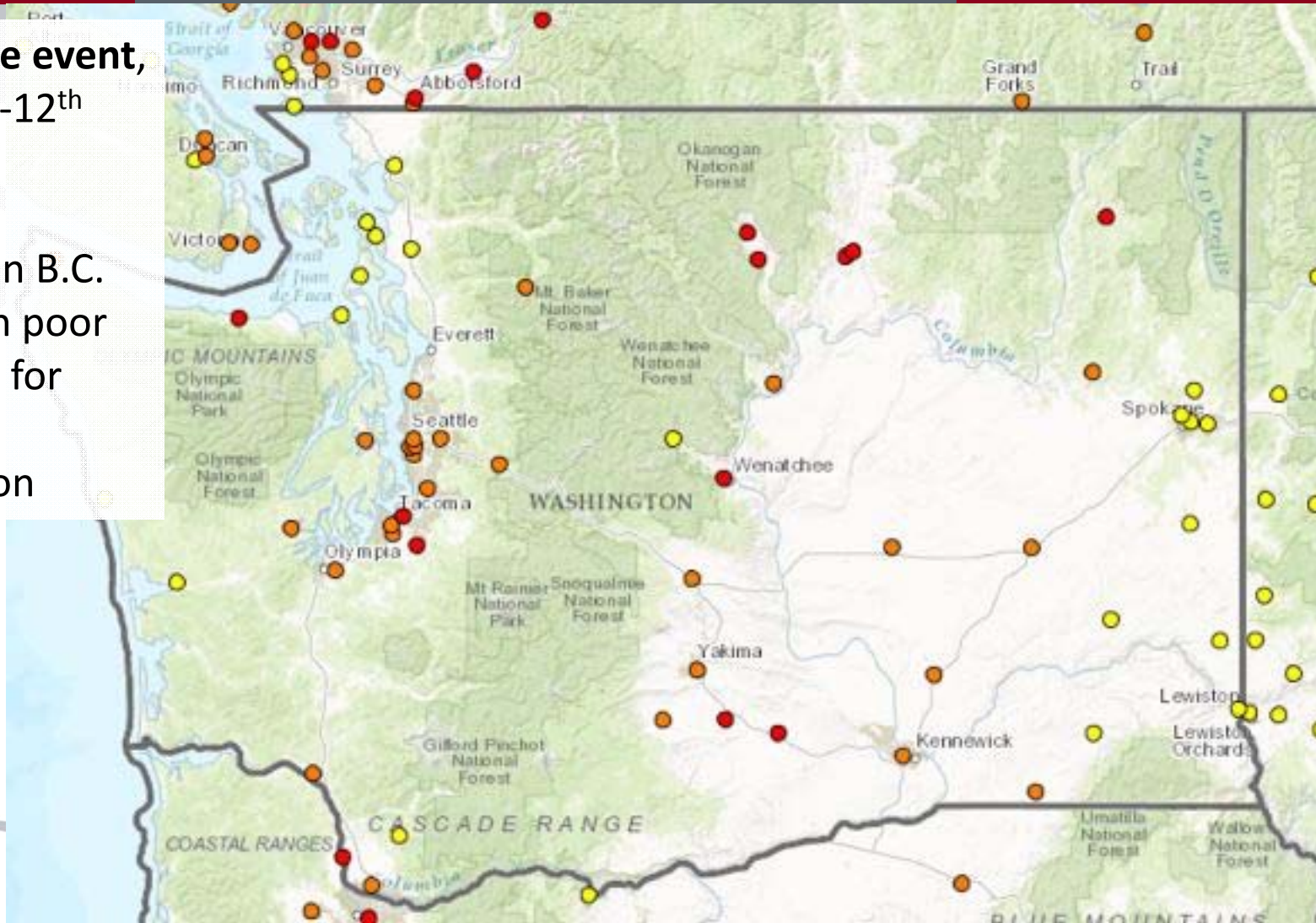
## Timing of smoke exposure



- All smoke exposure yielded some guaiacol
- Exposure seven days post veraison produced maximum
- Multiple exposures yielded additive amounts of guaiacol
- Kennison, et al, 2009

**B.C. smoke event,  
August 1<sup>st</sup>-12<sup>th</sup>  
2017**

Wildfires in B.C.  
resulted in poor  
air quality for  
much of  
Washington





## Air quality monitors

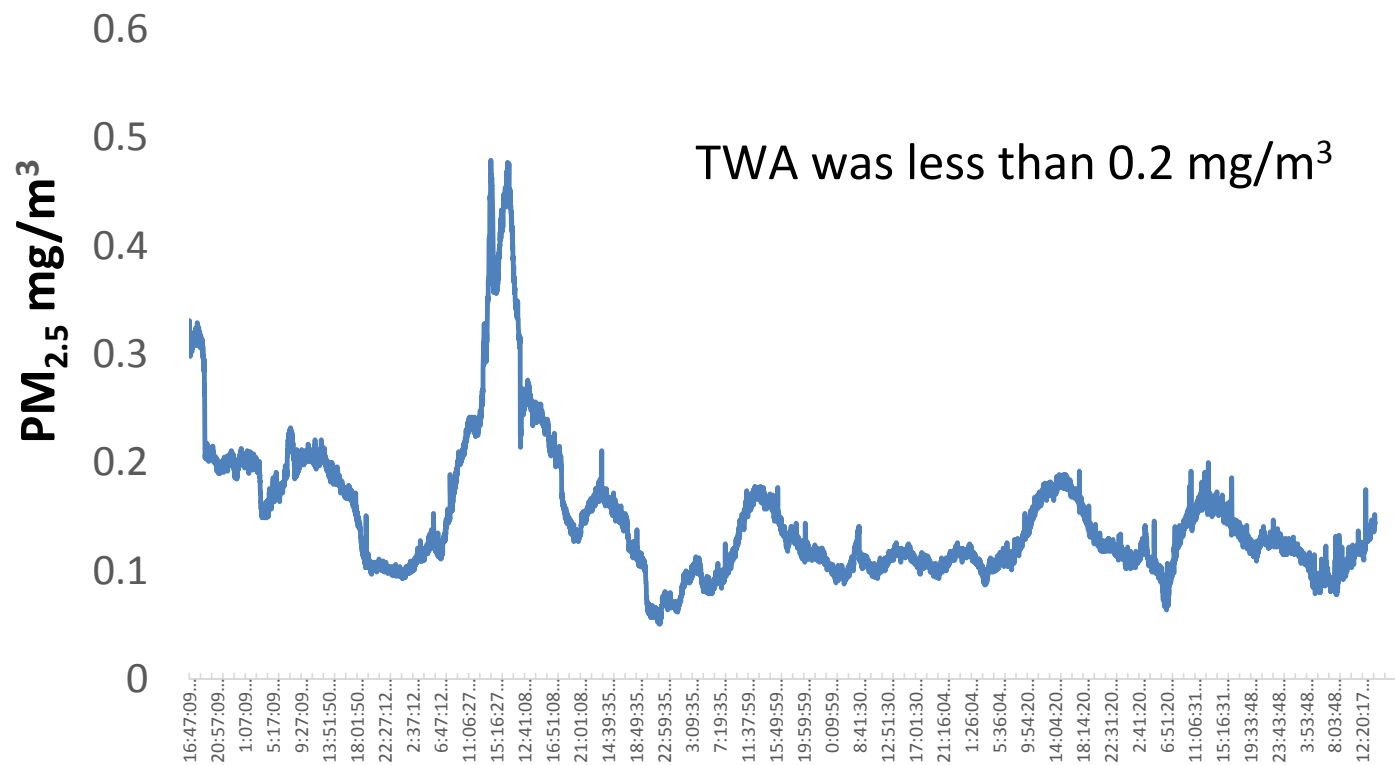
- Particle counters were used to monitor smoke density
  - PM 2.5, PM1.0
  - Particle size in microns
  - Particle size generally decreases during smoke events
    - Road dust—PM10.0
    - Smoke particles generally PM1.0 and smaller



# Smoke exposure at Roza vineyard, August 02-12, 2017



# Smoke exposure at Roza vineyard, August 02-12, 2017



## Smoke Exposure at Roza vineyard

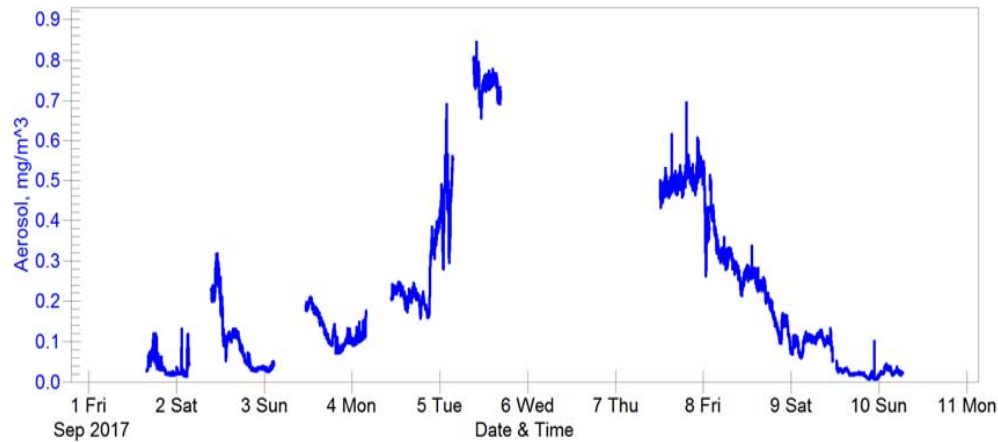
- Berry samples analyzed for presence of smoke related volatile phenols and glycosides
  - Samples collected from August 3<sup>rd</sup>-12<sup>th</sup> did not have observable levels of free compounds or glycosides
- Combination of relatively low smoke density and pre-veraison fruit limited the extent of smoke taint from this smoke event



**Labor Day Smoke  
Event, September  
5-8<sup>th</sup> 2017**

Smoke from Eagle  
Creek fire, Jolly  
Mountain and  
Norse Peak fires  
covered much of  
the Columbia Basin  
as well as the  
Columbia Gorge

PM2.5 Concentration  
0901\_0910 2017



Smoke from the Eagle Creek fire seen from the WA side of the Columbia river

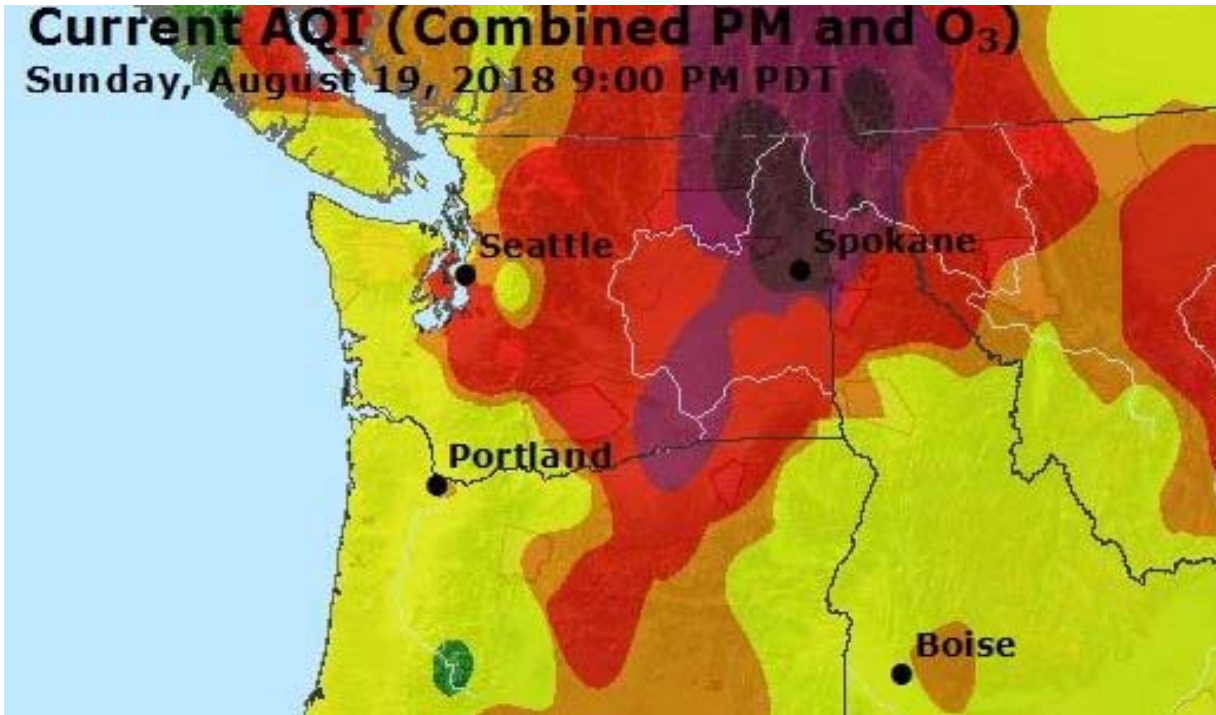
## Labor Day Smoke Event, September 5-8<sup>th</sup> 2017

PM<sub>2.5</sub> was much higher than for the BC event—ranged from 0.7-0.9 mg/m<sup>3</sup> at the Roza vineyard

Control wines from the smoking trials have detectable levels of smoke taint volatiles and glycosides

## Current AQI (Combined PM and O<sub>3</sub>)

Sunday, August 19, 2018 9:00 PM PDT

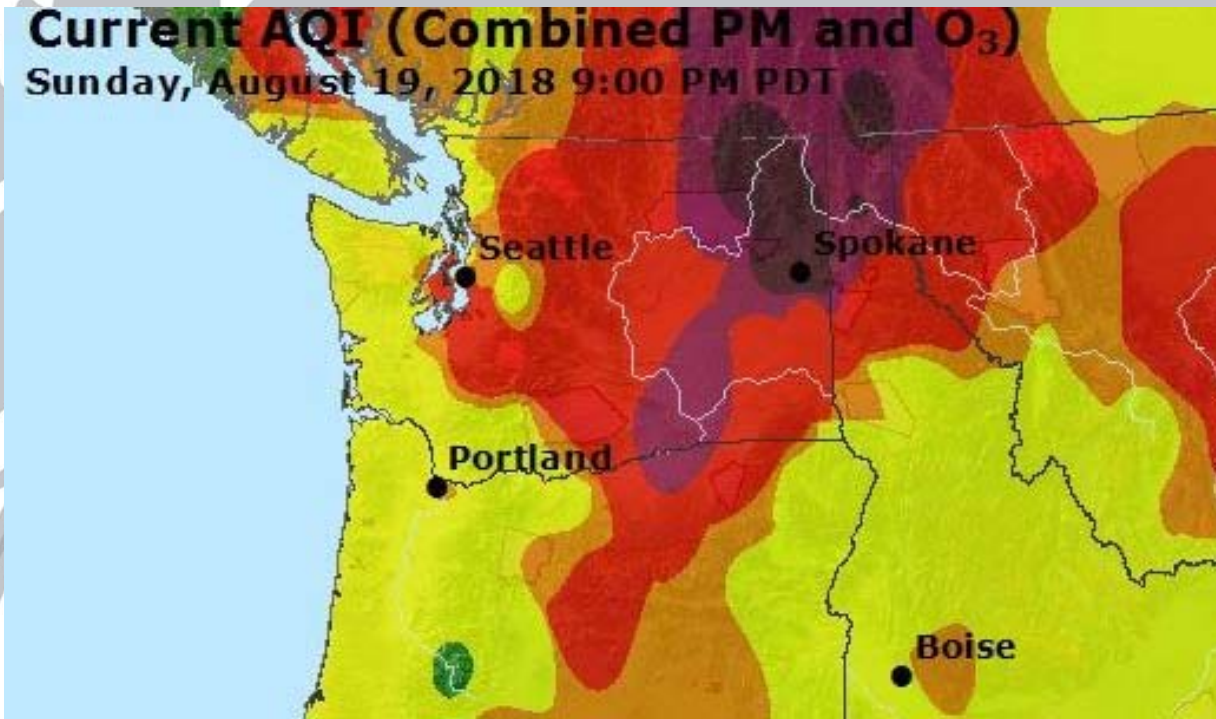


# Smoke event 08/19/2018

- Smoke from fires in Siberia & British Columbia drifted down into eastern Washington, Oregon and Idaho.
- PM<sub>2.5</sub> levels in excess of 2.0 mg/m<sup>3</sup> for several hours Sunday afternoon/evening

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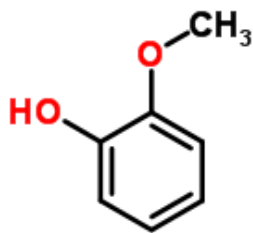
- Smoke from fires in Siberia & British Columbia drifted down into eastern Washington, Oregon and Idaho.
- PM<sub>2.5</sub> levels in excess of 2.0 mg/m<sup>3</sup> for several hours Sunday afternoon/evening
- In spite of the smoke density, this event did not result in appreciable smoke taint in affected areas

## Smoke Exposure at Roza vineyard, 2017

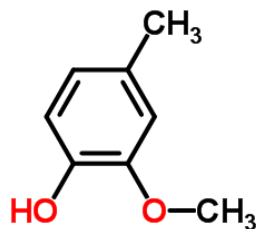
- Berry samples analyzed for presence of smoke related volatile phenols and glycosides
  - Samples collected from August 3<sup>rd</sup>-12<sup>th</sup> did not have observable levels of free compounds or glycosides
- Combination of relatively low smoke density and pre-veraison fruit limited the extent of smoke taint from this smoke event
  - Or so we thought at the time—it may be more related to low smoke density and the distance the smoke was carried to reach our site

## First smoke taint research report--2007

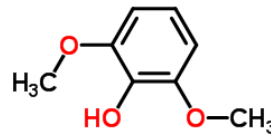
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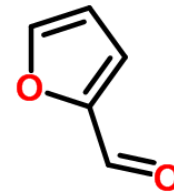
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4-methyl guaiacol



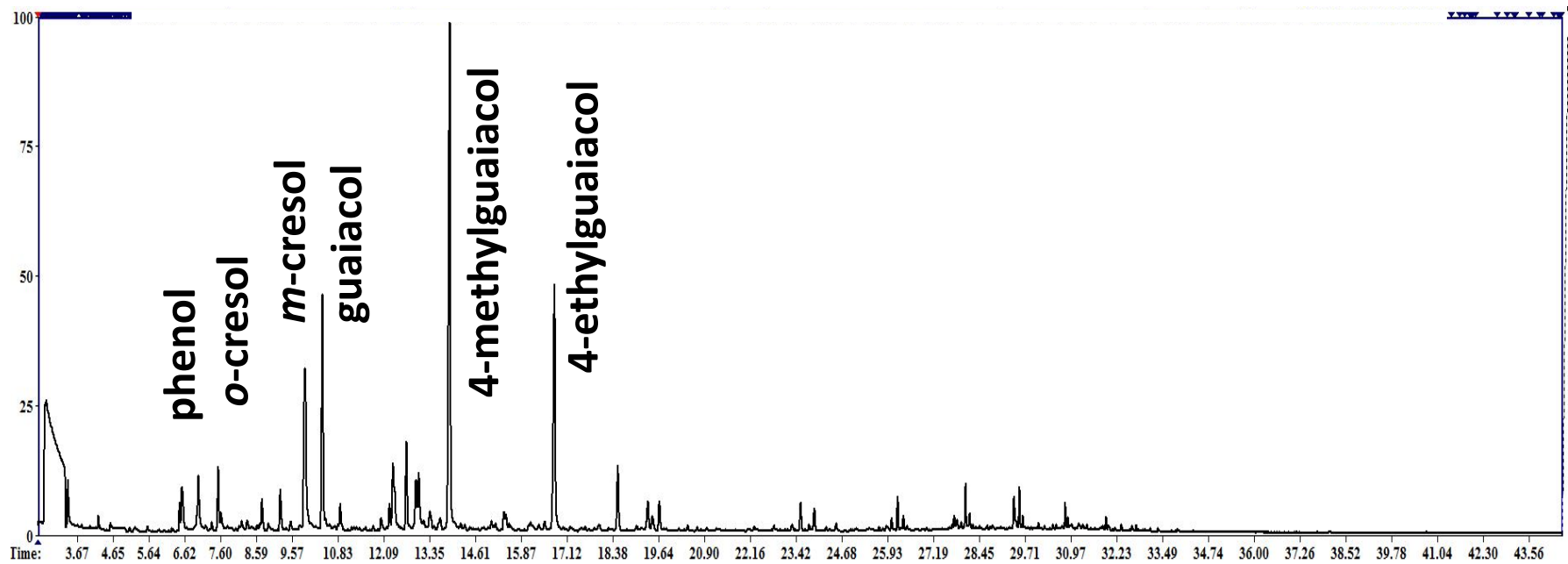
syringol



furfural

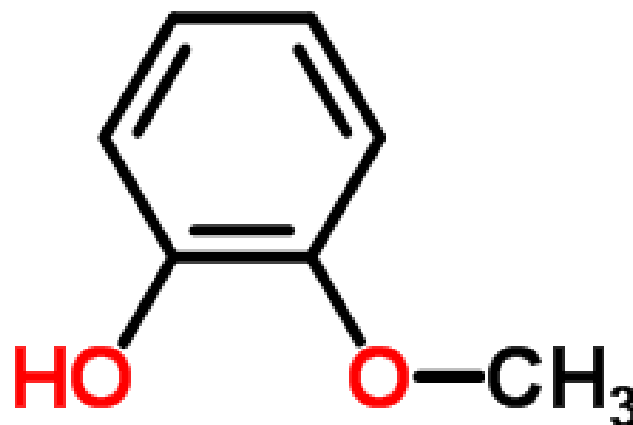
# Smoke from conifer bark

GC/MS chromatogram of smoke collected from burning conifer bark



## Guaiacol

Guaiacol is widely used as a marker for smoke exposure

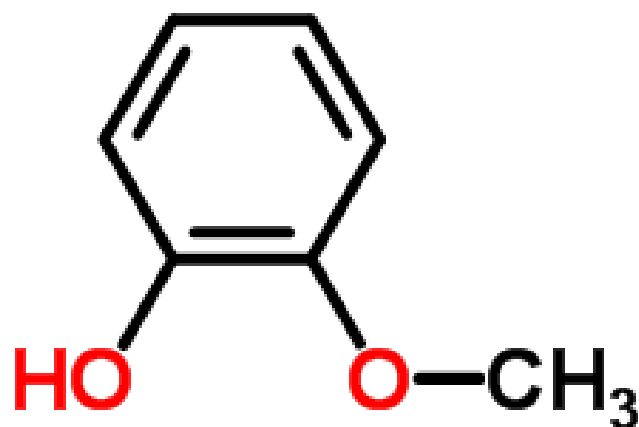


Guaiacol or 2-methoxy phenol

## Guaiacol

Guaiacol is widely used as a marker for smoke exposure

Guaiacol is produced by thermal degradation of lignin when wood or other plant material is burned

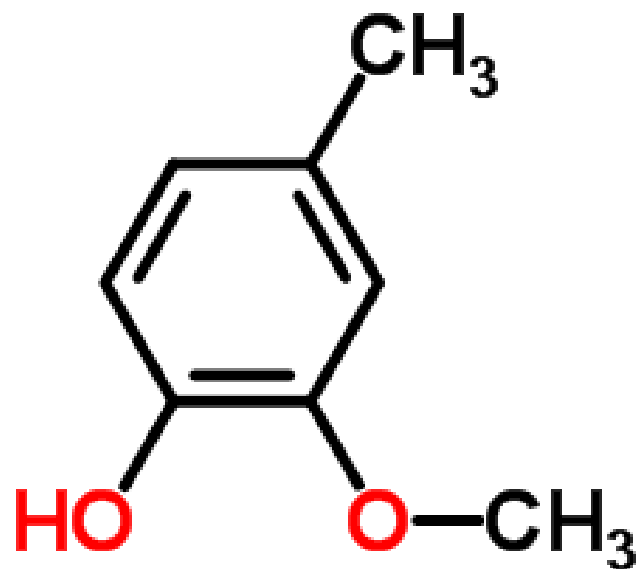


Guaiacol or 2-methoxy phenol

## 4-Methyl Guaiacol

4-methyl guaiacol is usually used along with guaiacol as a marker for exposure

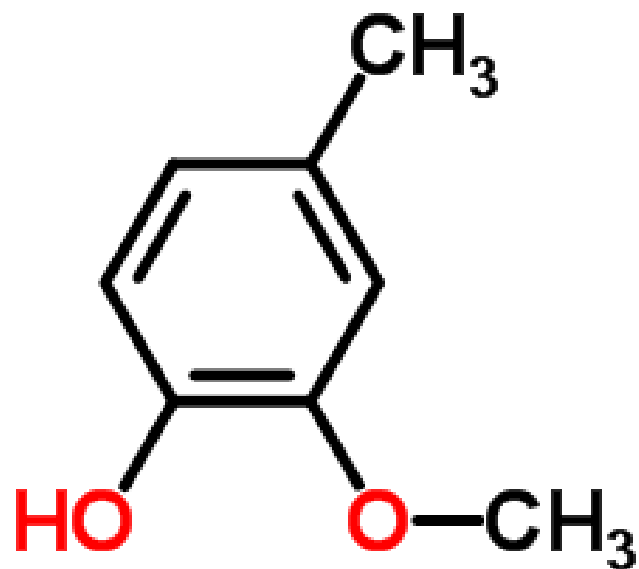
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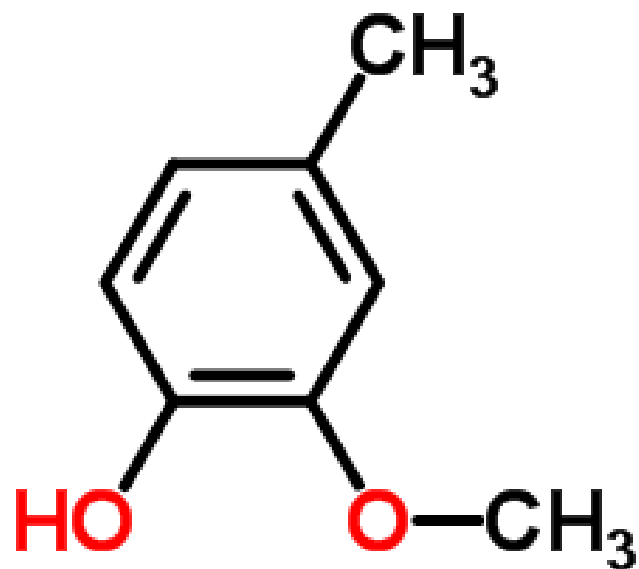


Both guaiacol and 4-methyl guaiacol are found in barrels, again from the thermal degradation of lignin in the oak wood

## 4-Methyl Guaiacol

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4-MG is also produced during the thermal degradation of lignin

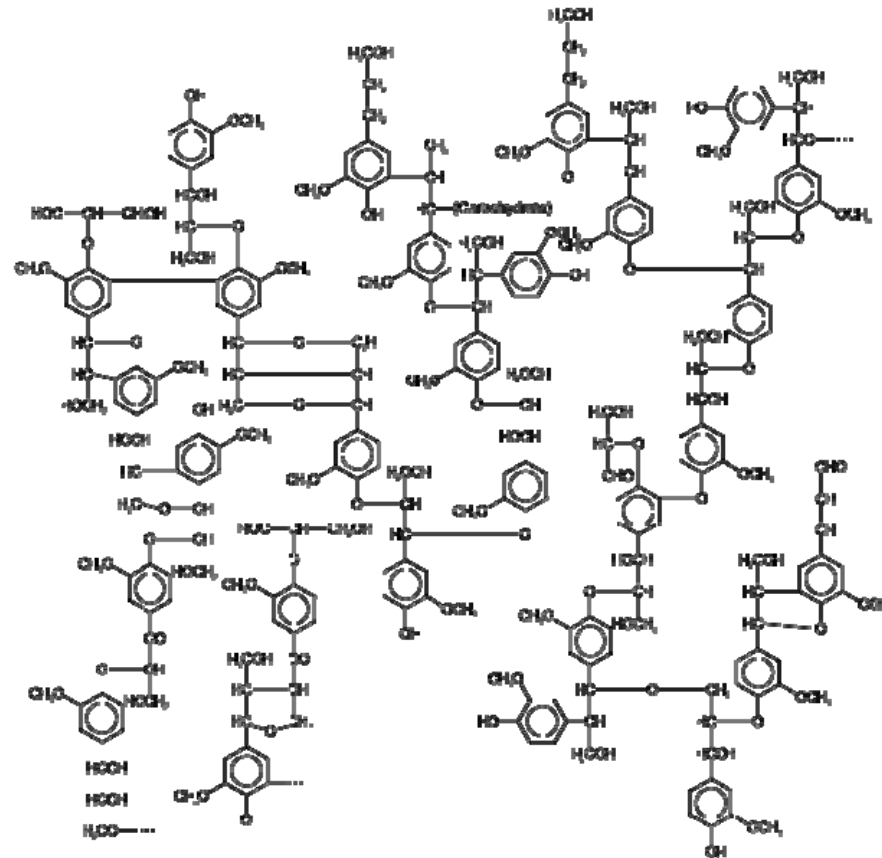


Guaiacol and 4-methyl guaiacol are good markers of smoke exposure but maybe not so good for the intensity of smoke perception

# Lignin

Lignin is an irregular highly cross-linked phenolic polymer

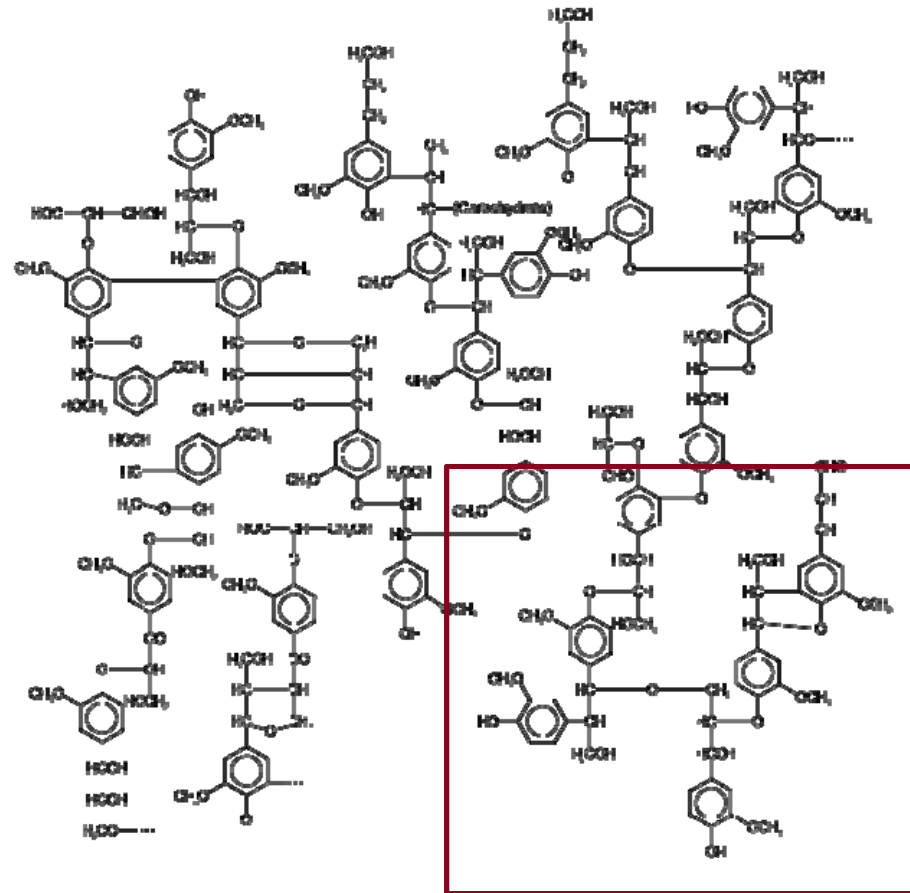
It cross-links with carbohydrate polymers such as cellulose to provide rigidity and strength to wood



# Lignin

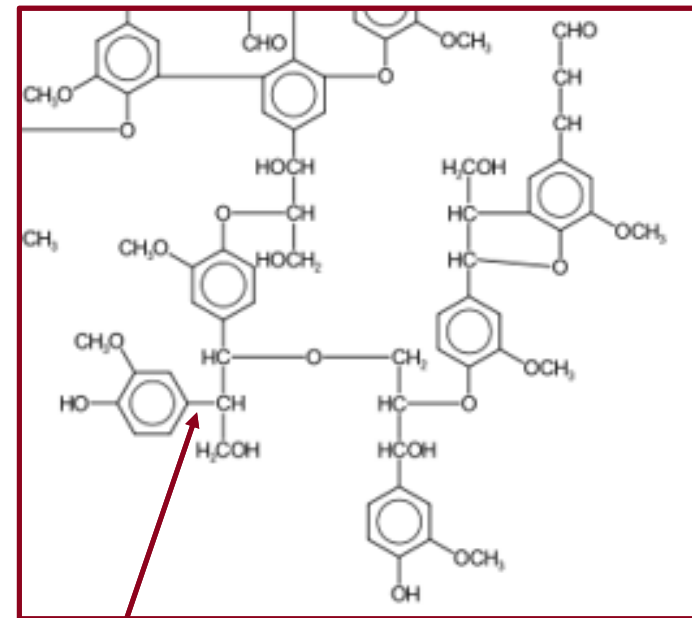
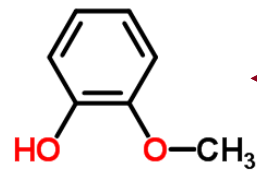
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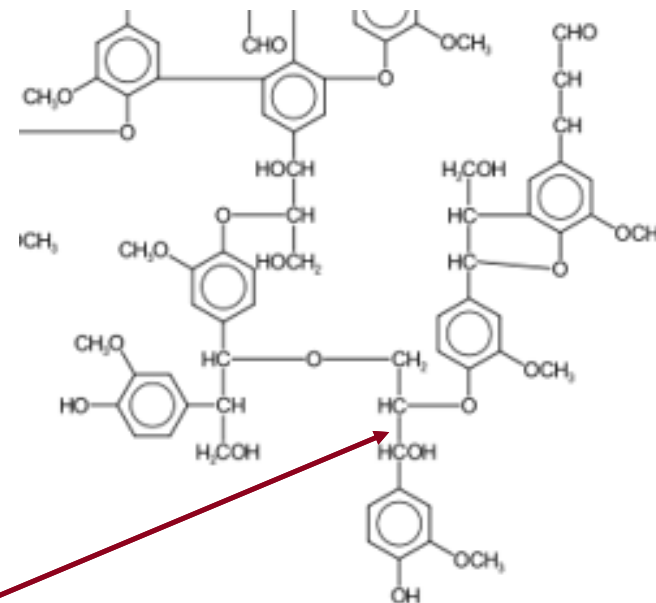
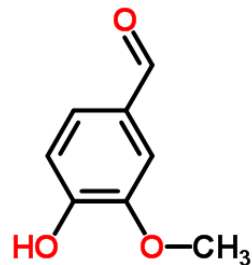
When lignin is heated, the bonds cross-linking the phenolic subunits can be cleaved, releasing guaiacol and other small volatile phenols



Cleave here to produce guaiacol

# Lignin

When lignin is heated, the bonds cross-linking the phenolic subunits can be cleaved, creating guaiacol and other small volatile phenols



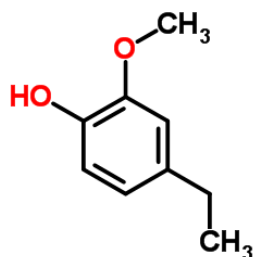
Cleave here to produce vanillin

## Volatile phenols

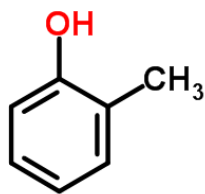
Thermal degradation of lignin produces a range of small volatile phenols

All of these compounds have been found in smoke affected wines

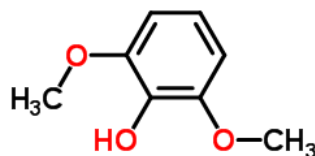
Parker *et al*, 2012 showed cresols could contribute to smoky character in wines



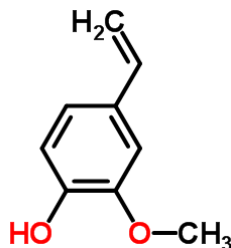
4-ethyl guaiacol



*o*-cresol



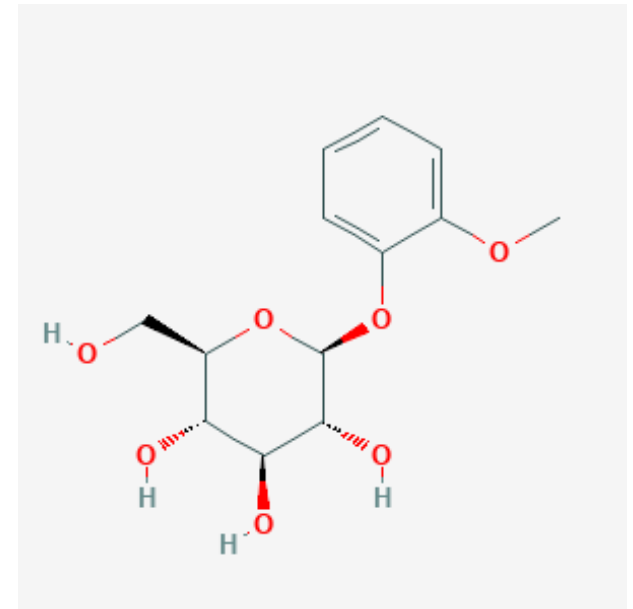
syringol



4-vinylguaiacol

## Smoke taint glycosides

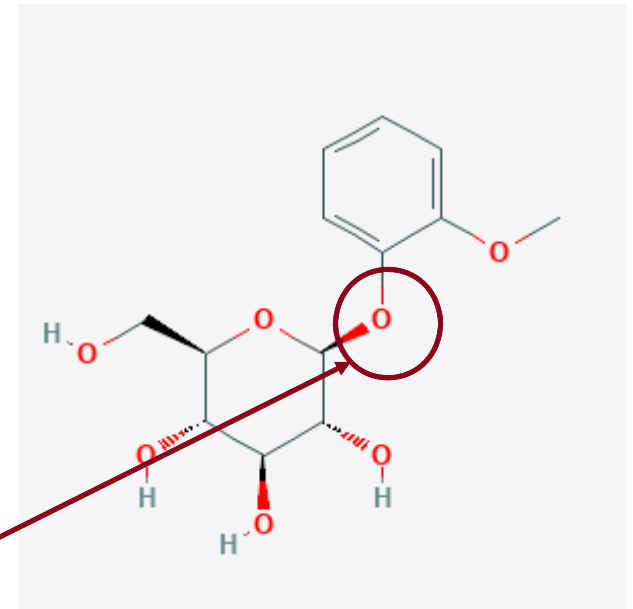
- In addition to the free volatile phenols, glycosides are also present
- Glycosides are less volatile than the free compounds and generally odorless
- Glycosidic bond is acid labile and can hydrolyze at wine pH



Guaiacol-glucoside

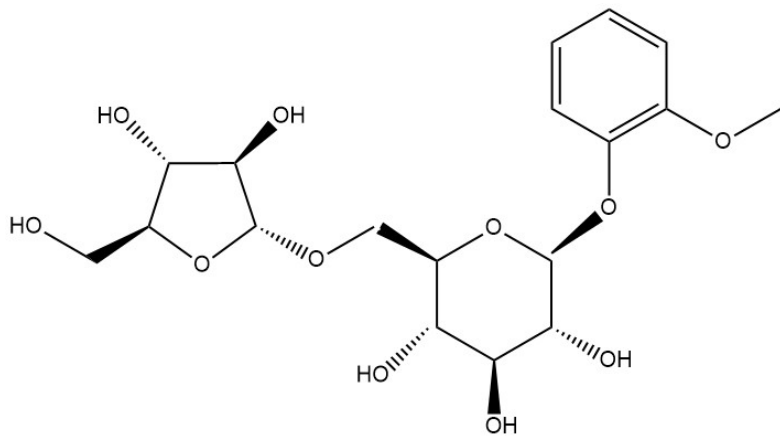
## Smoke taint glycosides

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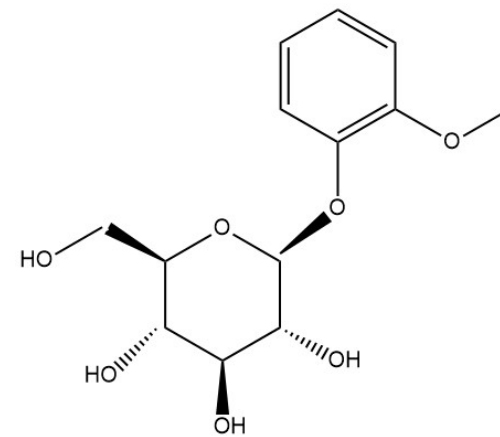


Guaiacol-glucoside

## Glycosides of smoke compounds

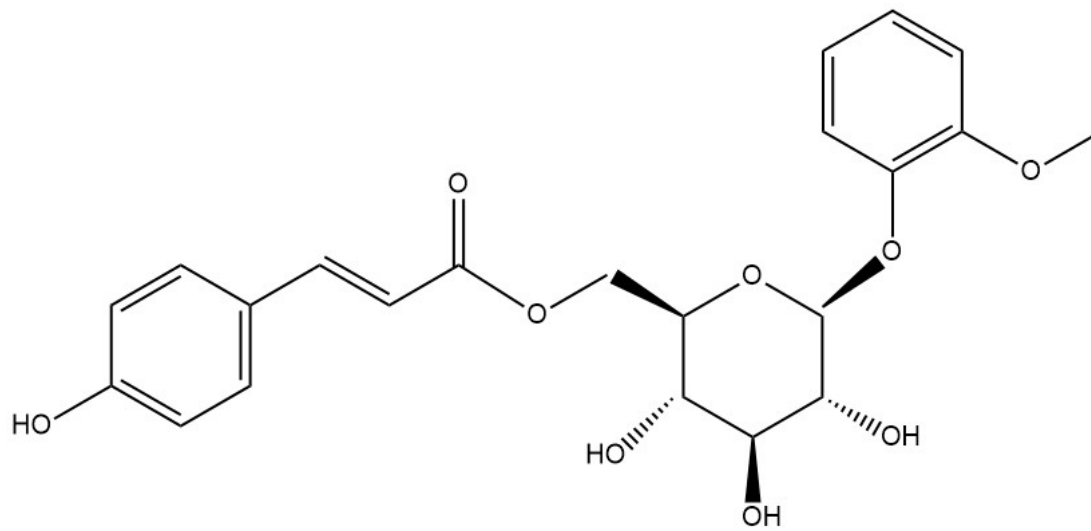


**Guaiacol, arabinosyl glucoside**



**Guaiacol, glucoside**

# Glycosides of smoke compounds



**Guaiacol, coumaroyl glucoside**

## Role of the glycosides in smoke taint

- Mayr, et al, 2014, reported that in a model system, the addition of both free volatile phenols and their glycosides produced the strongest off-aromas in a descriptive analysis experiment
  - Enzymatic activity in saliva hydrolyzes both mono- and di-saccharides
  - Variable hydrolysis dependent on glycosides present

## Wildfires and Wine

Two questions on everyone's mind:



View from the WSU Roza vineyard on 05 September 2017

## Wildfires and Wine

Two questions on everyone's mind:

How much smoke does it take to create the problem?



View from the WSU Roza vineyard on 05 September 2017

## Wildfires and Wine

Two questions on everyone's minds:

How much smoke does it take to create a problem?

Can the wines be treated?



View from the WSU Roza vineyard on 05 September 2017

## Assessing Risk of Smoke Taint



- Project initiated in 2016 with funds from the Washington Wine Commission to address these questions
- Develop a system to smoke vines at our research center near Prosser
  - 60 vines at a time, smoke and control
  - 18-48 hour exposures
  - Monitoring smoke intensity and composition
- Generate smoked fruit to make wines for mitigation studies

How much smoke does it take to create a problem?

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It depends



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How much smoke does it take to create a problem?

It depends:

On the smoke  
fuel source



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How much smoke does it take to create a problem?

It depends:

On the smoke  
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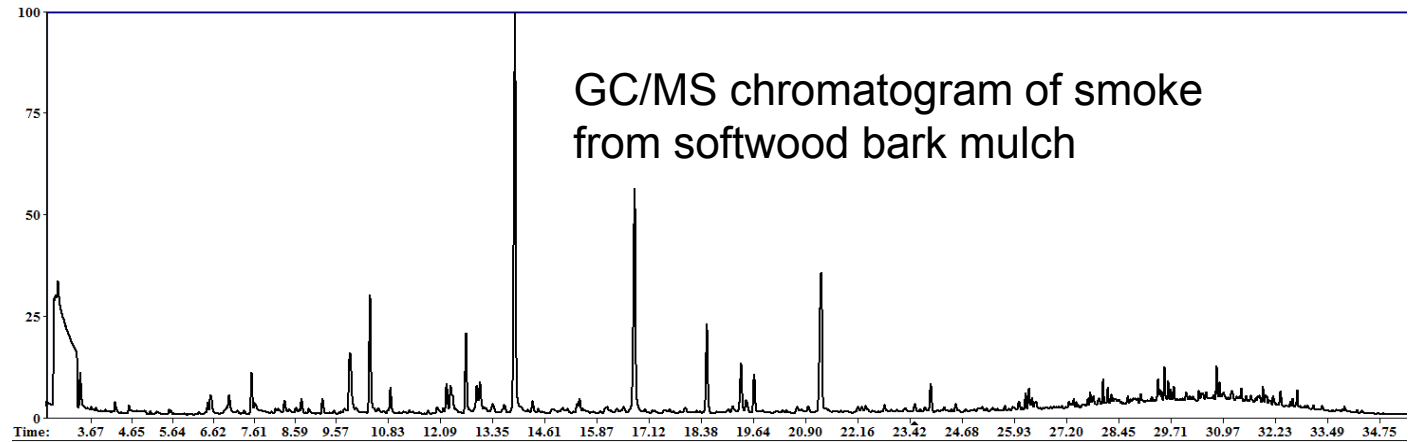
On the smoke  
fuel source  
proximity of the fire

On timing of the fire relative to  
berry development (?)

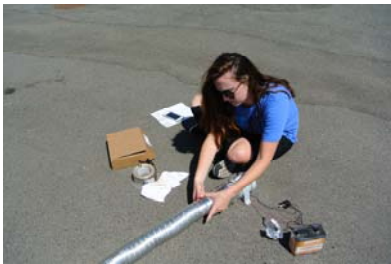


View from the WSU Roza vineyard on 05 September 2017

# The role of fuel source

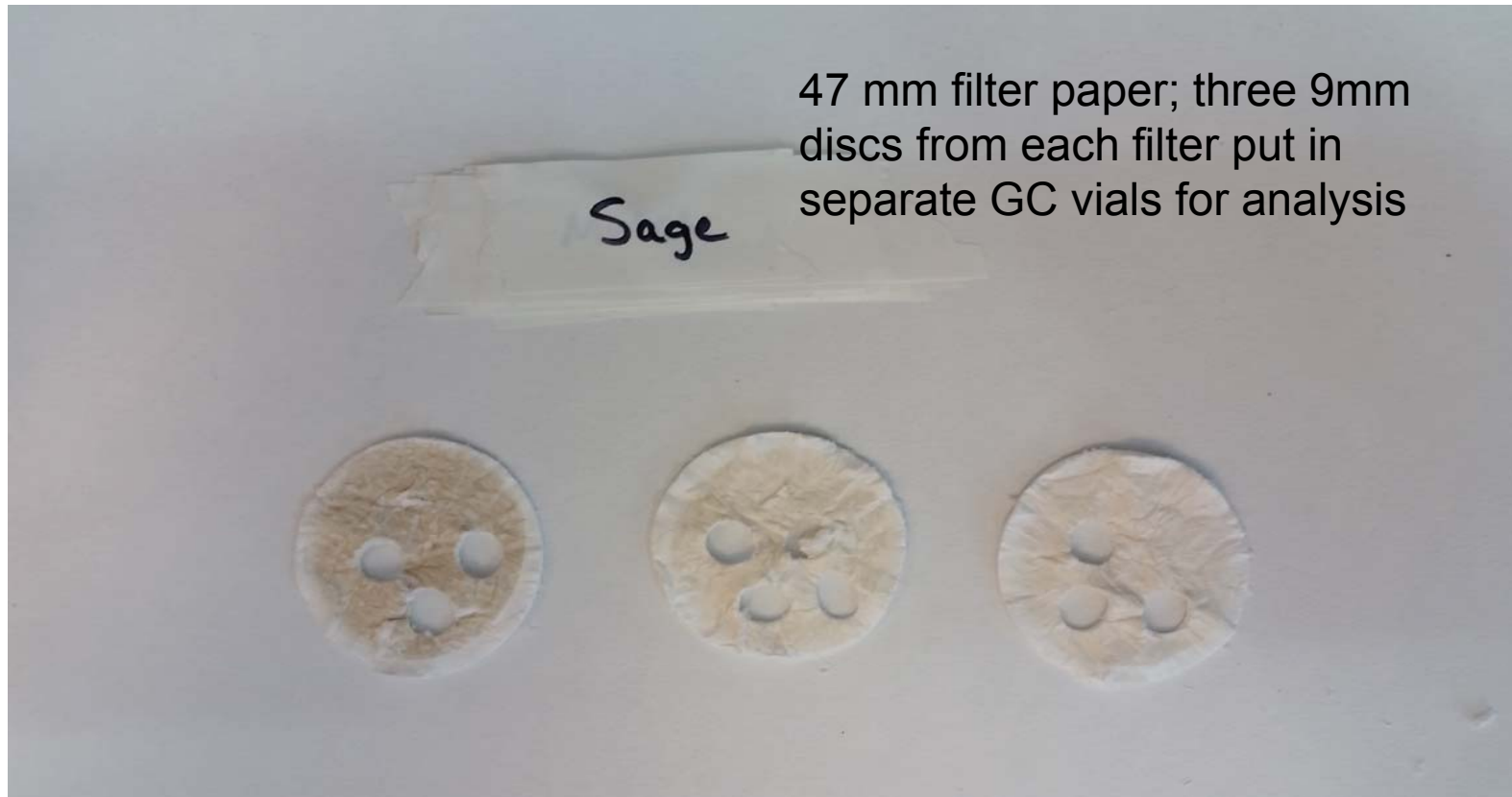


Sampled smoke from 15 plant species commonly found in rangeland of eastern Washington



Controlled conditions, smoke collected on 47 mm filter papers

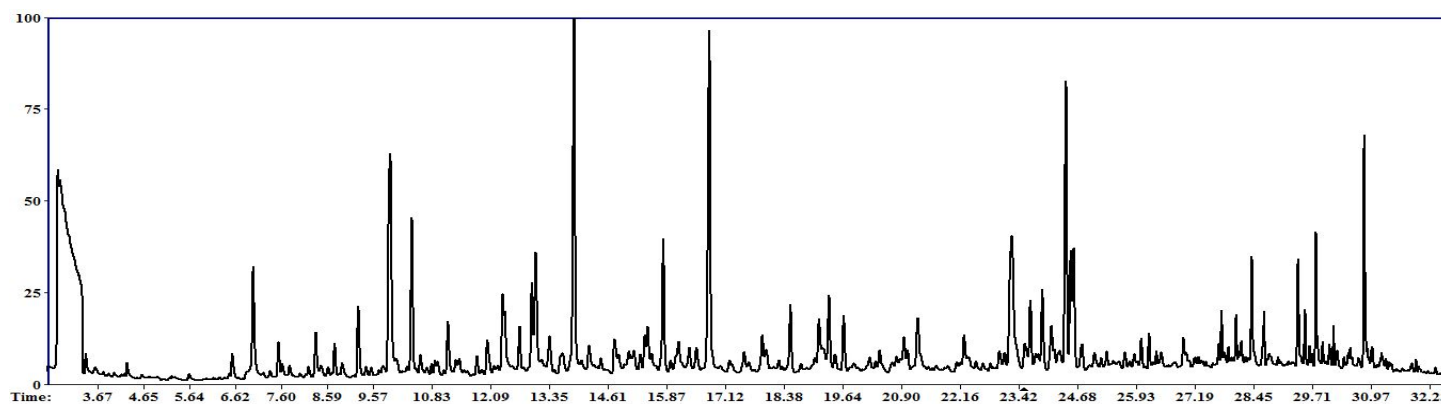
## Filters for Big Sagebrush



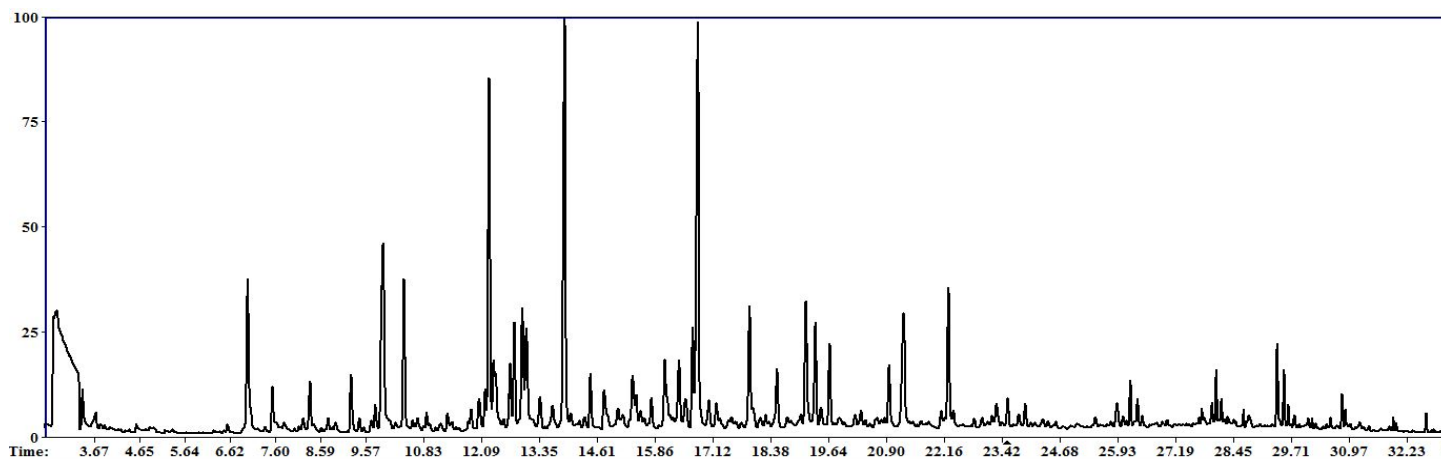
## Rabbit brush and sage GC/MS Chromatograms

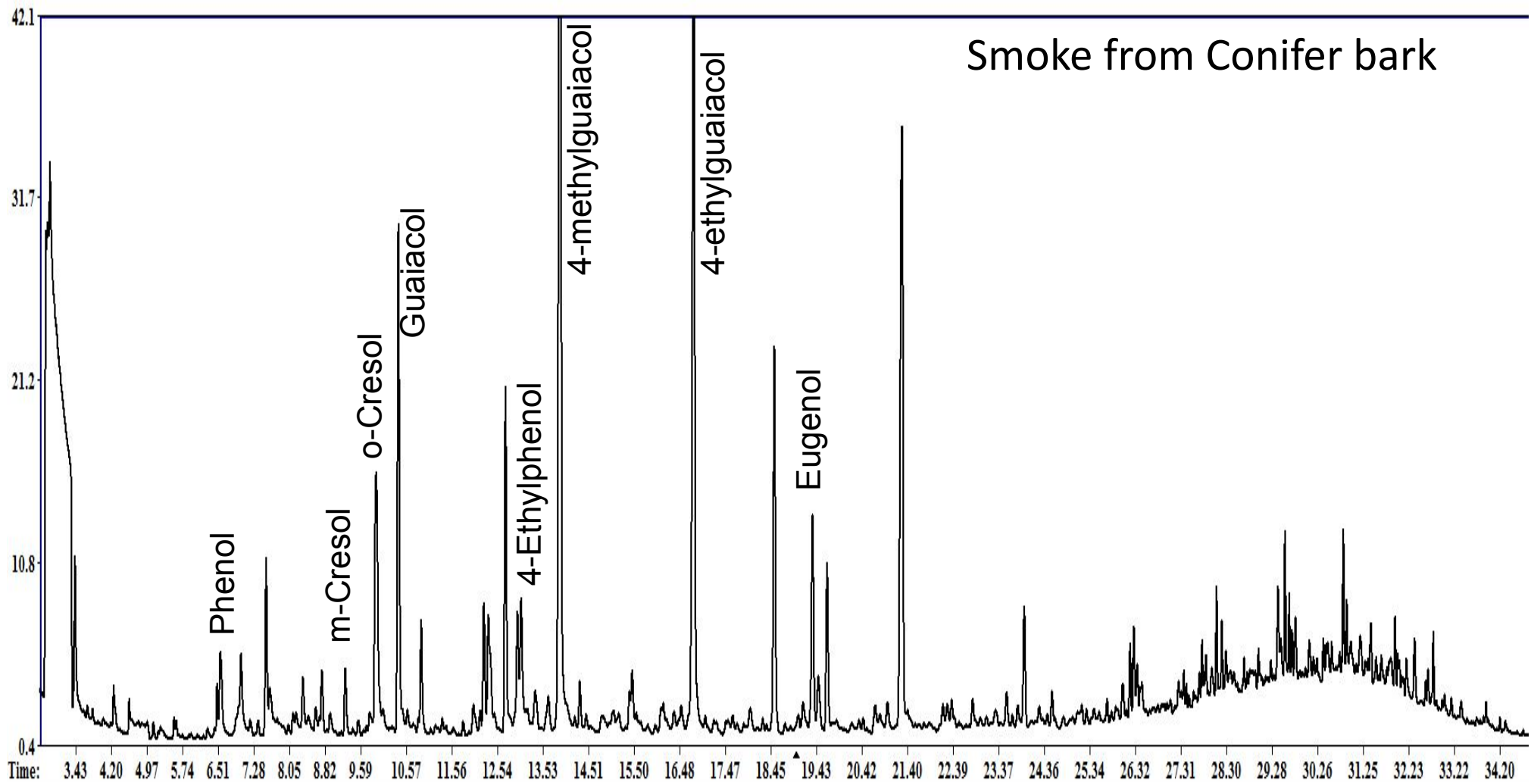


Rabbit brush

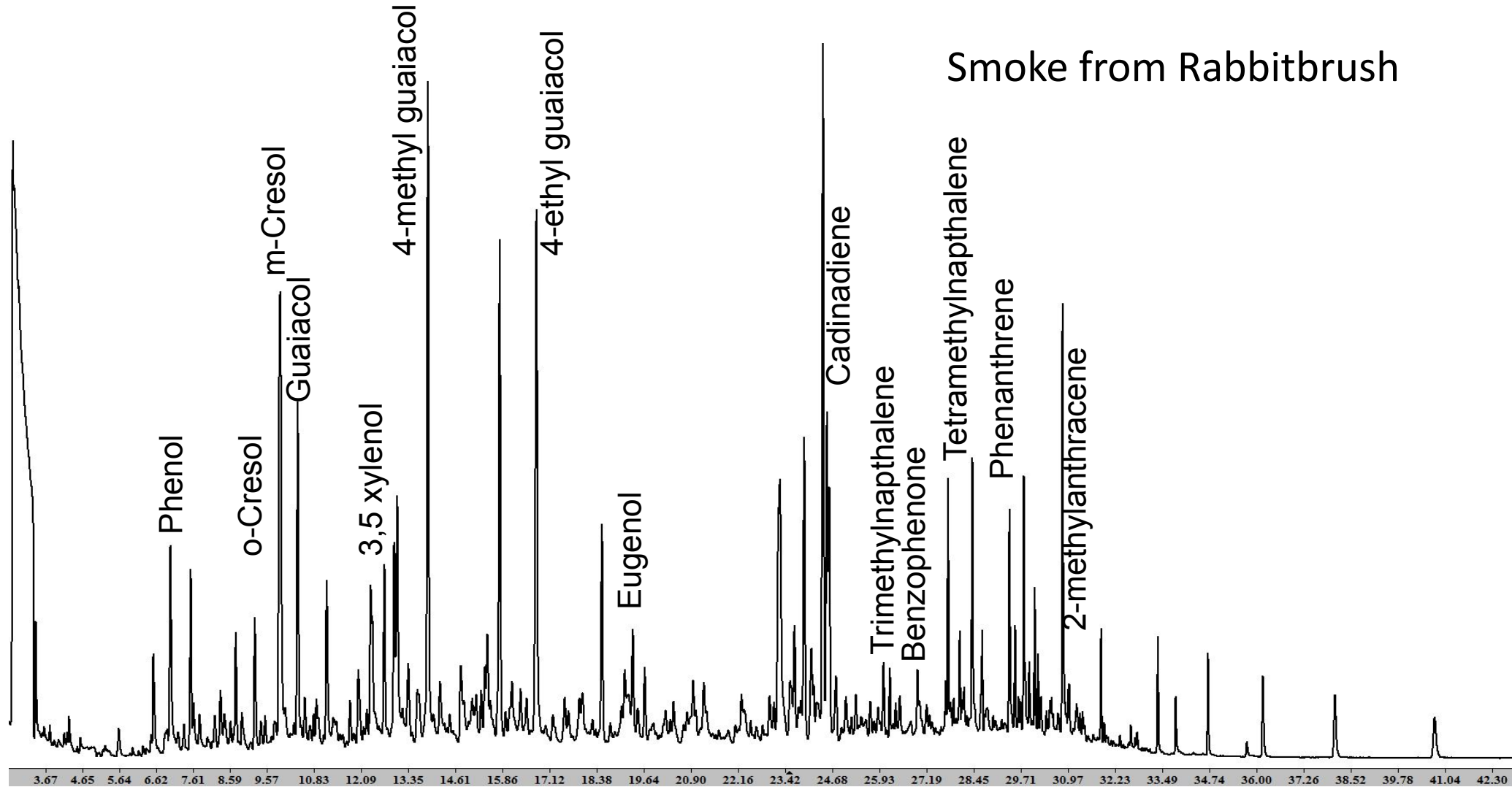


*Artemisia tridentata*:  
Big Sagebrush





# Smoke from Rabbitbrush



## Rabbit brush tar



Gray rabbit brush (*Ericameria nauseosa*) was evaluated during WWII as a source for natural rubber and other resins.

The species name “nauseosa” refers to the foul aromas that arise when the leaves or flowers are crushed (or burned, as it turns out!)



## 2017 Smoking Trials

- Impact of fuel source
  - Chardonnay and Merlot smoked with proprietary blend of rangeland plant materials
  - Cabernet smoked with mix of conifer bark mulch
- 26-48 hour exposures
  - Increase from 2016
- Wines made from exposure to smoke from rangeland fires express different aromas than wine from bark mulch smoke

## Wildfires and Wine

How much smoke does it take to create a problem?

It depends:

On the smoke

fuel source

flaming vs smoldering fires

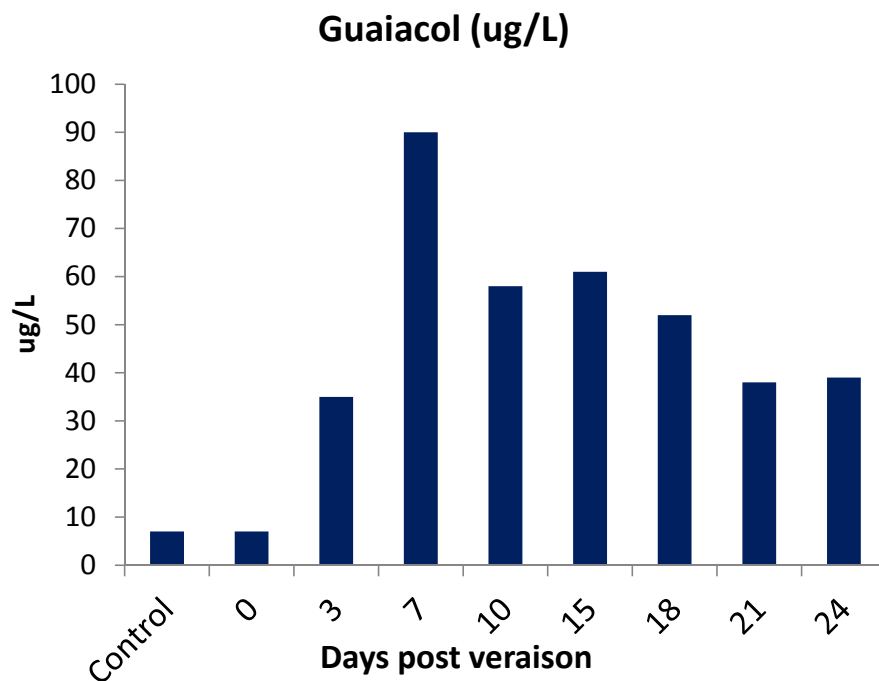
proximity of the fire

On timing of the fire relative to berry development



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# 2018 Smoking trials

- Timing of smoke exposure relative to berry development
  - Pre-véraison
  - At véraison
  - 3 weeks post véraison
  - 6 weeks post véraison



# 2018 Smoking trials

- Timing of smoke exposure relative to berry development
  - Pre-véraison
  - At véraison
  - 3 weeks post véraison
  - 6 weeks post véraison
- All of the wines from this trial have smoke taint, including the wines made from fruit smoked 4 weeks pre-veraison
  - Wine from pre-veraison unsmoked control are not tainted, in spite of the smoke from the August 2018 event



# 2018 Smoking trials

- Timing of smoke exposure relative to berry development
  - Pre-véraison
  - At véraison
  - 3 weeks post véraison
  - 6 weeks post véraison
- Australian work had suggested the risk pre-véraison was lower than post-véraison, but not zero
  - We plan to conduct an even earlier smoking in 2019, plus confirmation of results from 4-weeks pre-véraison smoking in 2018



## Key Take-aways

- Smoke related compounds are present both as free compounds and as glycosides
  - Free compounds responsible for wine aromas
  - Glycosides play a role in the flavor/aftertaste
  - Glycosides hydrolyze over time to release more free compounds
- Smoke composition varies with plant source; differences in smoke composition affect the aromas and flavors in the resulting wines
- Smoke exposures both pre- and post-veraison can result in smoke affected fruit and wine

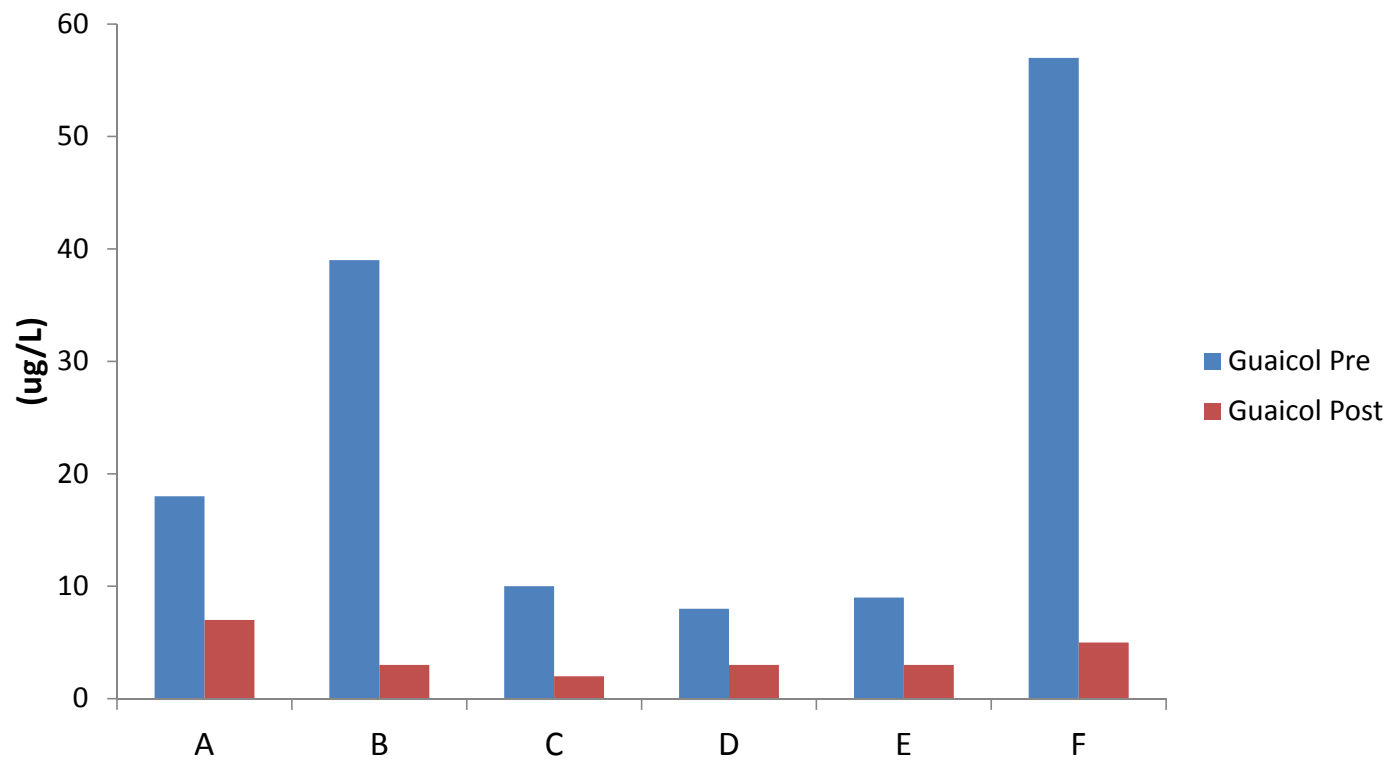
Thank you!



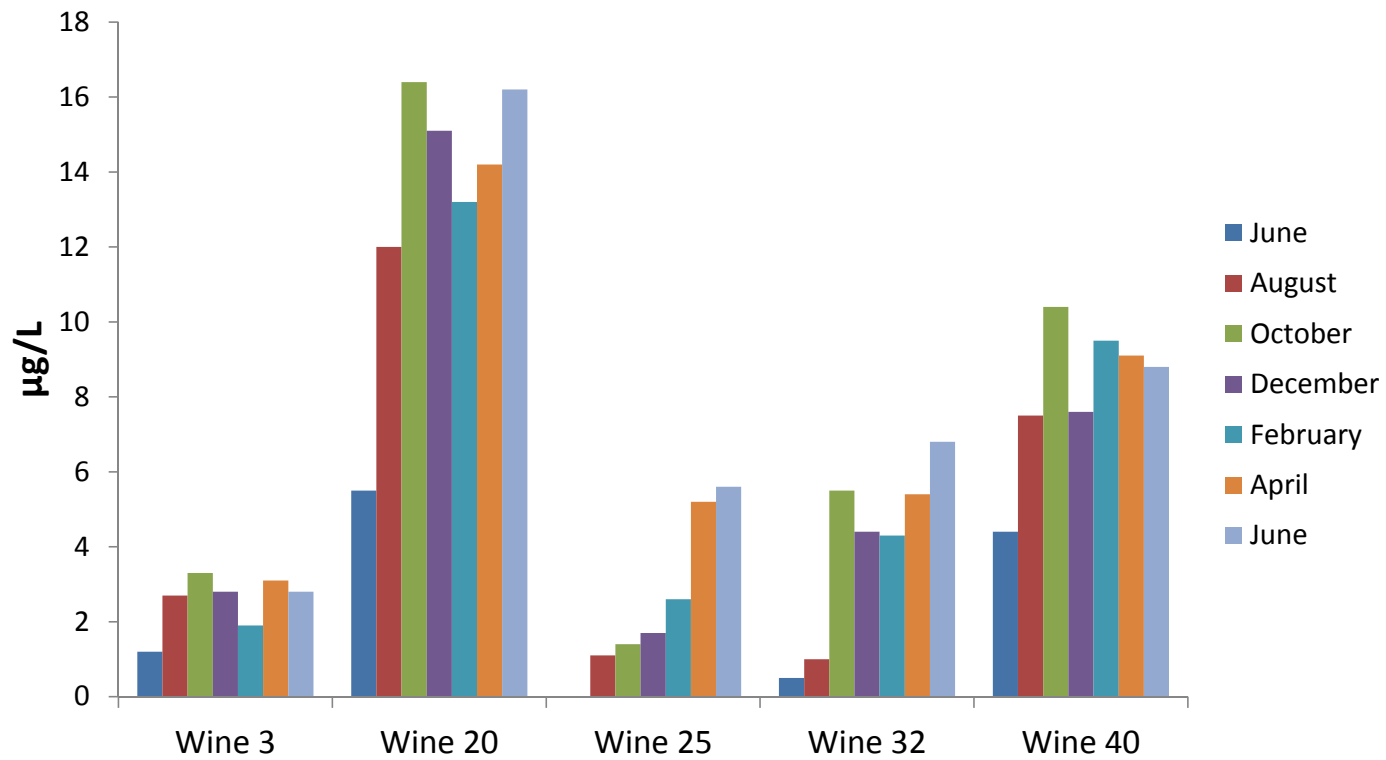
Viticulture & Enology Program

WASHINGTON STATE UNIVERSITY

# R.O. treatment of six 2008 red wines



# Guaiacol content of R.O. treated wines over time



# Guaiacol released by strong acid hydrolysis one year after R.O. treatment

