# Preventing Smoke-Taint in the Vineyard

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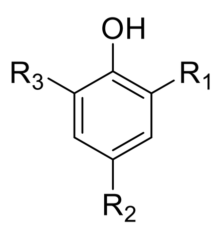
## Abstract

Research has demonstrated that the waxy cuticular layer of the grape is involved in the uptake of the presumptive causative agents of smoke-taint (*i.e.*, volatile phenols; VPs) during smoke exposure, but the cuticle also serves a protective role by insulating grapes from environmental factors (like exogenous VPs). Given this dominant ingress mechanism (minor foliar uptake has also been demonstrated), one approach that has not been extensively explored in the peer-reviewed literature is the use of protective sprays to limit the uptake VPs into the berry during smoke-exposure. Accordingly, this study evaluated several commercial products with spray-based application for their ability to limit the uptake of VPs. More specifically, a wax-based biofilm (BIOFILM) and two oil-based fungicidal sprays (OIL 1 and OIL 2) were evaluated in this work for their ability to insulate grapes from the effects of wildland fire smoke. While none of these products were designed for protecting grapes against smoke-taint, investigating their use in this regard is an important research avenue with the potential to provide a broadly applicable solution to mitigate smoke-taint in the vineyard.

Our results indicate that the wax-based biofilm, applied one week before smoke exposure, reduced the concentration of free and bound VP smoke-taint marker compounds in Pinot Noir grapes by up to 400% when compared to grapes that did not receive the spray treatment. The oil-based sprays did not appreciably change the detected concentrations of smoke-taint marker compounds in Pinot Noir grapes, suggesting that their use to control smoke-associated fungal issues is not likely to make smoke-taint worse. As a preliminary study, these data strongly suggest a path forward that will provide viticulturalists with a viable tool to help protect their grapes in the face of more frequent and severe wildland fire seasons.

## Introduction

| compound | $R_1$ | $R_2$ | $R_3$ |
|---|---|---|---|
| 4-ethylguaiacol | OMe | Et | H |
| 4-ethylphenol | H | Et | H |
| 4-methylguaiacol | OMe | Me | H |
| guaiacol | OMe | H | H |
| eugenol | OMe | $C_3H_5$ | H |
| *o/m/p*-cresol | H (Me) | H (Me) | H (Me) |
| syringol | OMe | H | OMe |
| phenol | H | H | H |





volatile phenol sensory attributes

**Figure 1.** Smoke-exposure does no always mean perceptible smoke-taint (top). Some of the negative sensory aspects of smoke-taint correlate to a suite of organoleptic volatile phenols (VPs, bottom)[1] that are produced during the combustion of plant matter and carried in the smoke to vineyards where they can accumulate in the berries and are subsequently extracted into the wine.

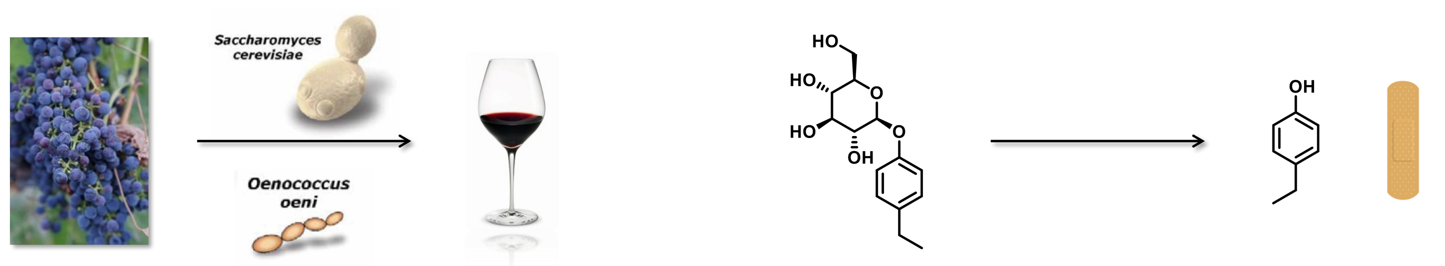



**Figure 2.** VPs can be stored as an array of glycosides[2]. Yeast, bacterial and grape enzymes may release the free VP during fermentation or aging, increasing the intensity of smoke-taint. After release, the free VPs will have a direct impact on the intensity of perceptible smoke taint.

**How can we mitigate the impact of forest fire smoke on wine quality?**

## Viticultural Details

| parameter | vineyard 1 [a] | vineyard 2 | vineyard 3 |
|---|---|---|---|
| latitude/longitude | 49.7694° N/119.5306° W | 49.7604° N/119.5418° W | 49.8428° N/119.5661° W |
| year planted | - | 2000 | 2006 |
| clone-rootstock | - | 67-101/14 | 828-SO4 |
| row orientation | NW-SE | N-S | N-S |
| clusters/vine | 20-30 | 10-15 | 15 |
| yield (T/ac) | 2.8 | 2.4 | 1.5 |
| °Bx [b] | 23.4 | 24.1 | 25.4 |
| TA [b] | 8.1 | 6.6 | 8.5 |
| pH [b] | 3.48 | 3.48 | 3.47 |
| spray [c] | OIL 1 | OIL 2 | BIOFILM |

**Table 1.** Viticultural details of the three blocks of Pinot noir used for field trials. All vines were trained to vertical shoot positions with 1.3 m spacing between vines. [a] age, clone, rootstock not available for vineyard 1. [b] the °Bx, TA and pH values are aggregates from each block. [c] sprays were applied to complete foliar and fruit coverage at a 1% (*v/v*) dilution.

## Methods [3,4]

Field trials → Sample processing → Sample analysis

*Pinus ponderosa* fuel

**free VPs**

homogenize → extraction

**total VPs**

homogenize → acid digestion → extraction

GC-MS/MS

Thermo Trace1310 GC
Thermo TSQ9000 AEI MS/MS
ZB-5MSplus,
30m x 0.25mm x 0.25µm

## Study Design

| | days relative to veraison [a] | | | | |
|---|---|---|---|---|---|
| **time-point** | t1 | t2 | t3 | t4 | t5 |
| **description** | after spray | before smoke | smoke 1 | smoke 2 | harvest [a] |
| **vineyard 1** | | | | | +32 |
| **vineyard 2** | +7 | +14 | +14 | +16 | +30 |
| **vineyard 3** | | | | | +21 |

**Table 2.** Time-points collected at each vineyard and a description of each time-point. [a] veraison and harvest decisions were made by the staff at each of our partner vineyards.

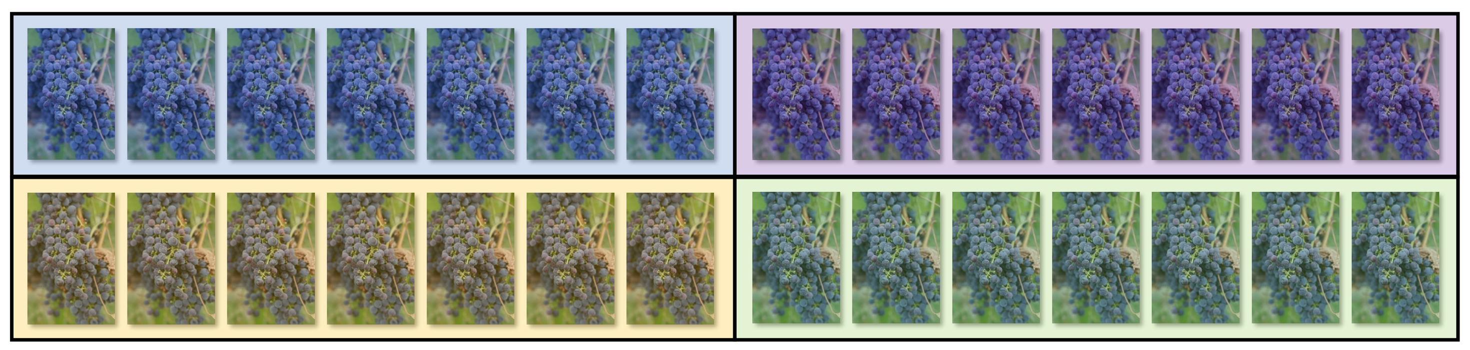



**Figure 3.** The division of biological replicates within each vineyard (*i.e.*, the number of replicates for each treatment group collected per time-point). Control and smoked vines were separated by one row or at least one panel.

## Vineyard 1 – OIL 1

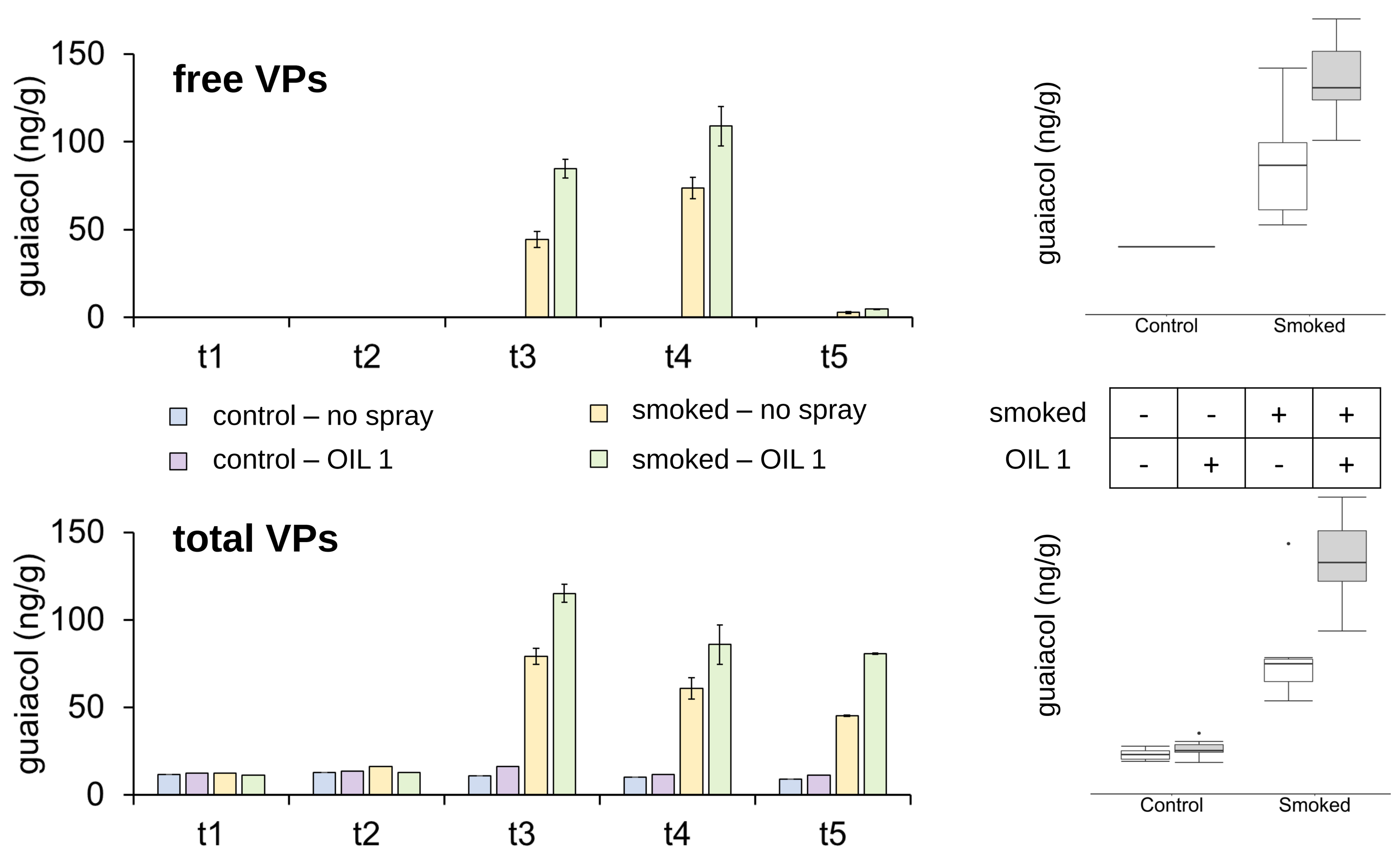



**Figure 4.** Field trial results for guaiacol after the application of OIL 1. The free (top left) and total VP data (bottom left) demonstrated that OIL 1 increases the concentration of free and total VPs. Box-whisker plots (right) highlight the observed differences at commercial maturity (t5). Similar results were observed for other VPs evaluated at vineyard 1. Bar graph data are shown as the mean ±1 SEM. For box-whisker plots, center lines show medians, box limits indicate the 25th and 75th percentiles, whiskers extend to 1.5 times the interquartile range from the 25th and 75th percentiles and points beyond these ranges were assigned as outliers.

**OIL 1 may increase the severity of smoke-taint in treated grapes**

## Vineyard 2 – OIL 2

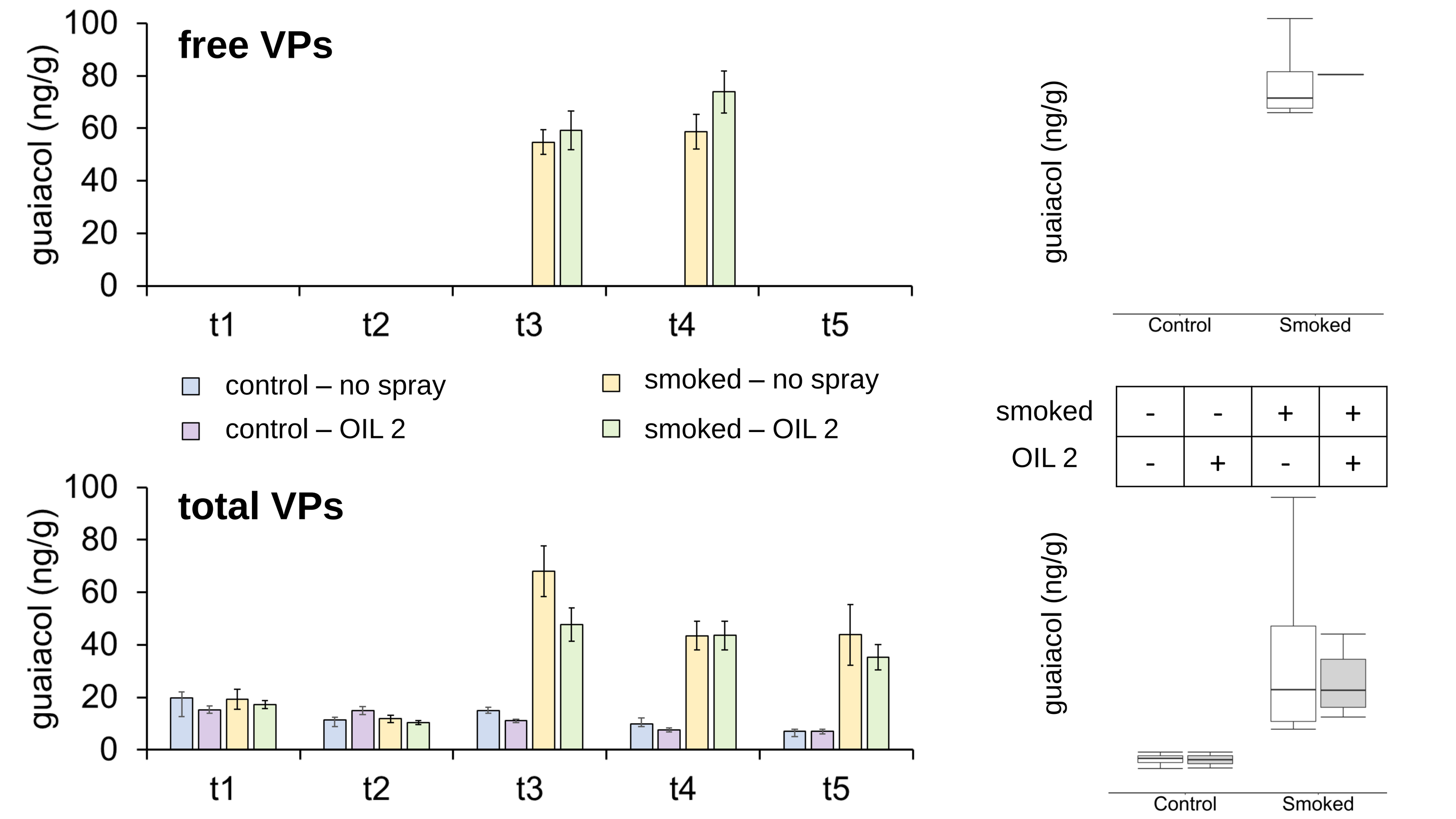



**Figure 6.** Field trial results for guaiacol after the application of OIL 2. The free (top left) and total VP data (bottom left) demonstrated no significant difference across treatment groups. Box-whisker plots (right) highlight the observed differences at commercial maturity (t5). Similar results were observed for other VPs evaluated at vineyard 2. Bar graph data are shown as the mean ±1 SEM. For box-whisker plots, center lines show medians, box limits indicate the 25th and 75th percentiles, whiskers extend to 1.5 times the interquartile range from the 25th and 75th percentiles and points beyond these ranges were assigned as outliers.

**OIL 2 does not impact the concentrations of free or total VPs**

## Vineyard 3 – BIOFILM

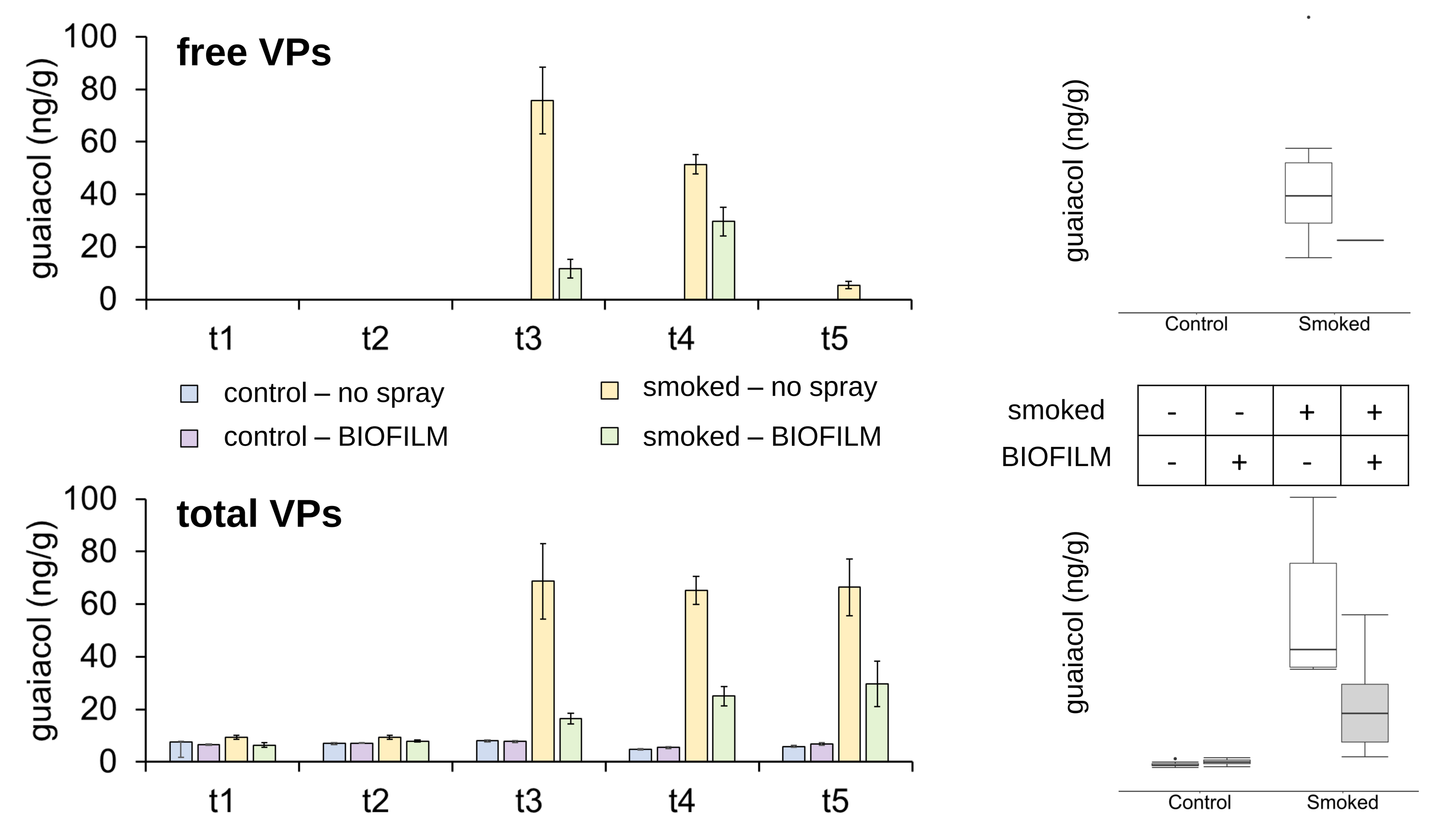



**Figure 6.** Field trial results for guaiacol after the application of BIOFILM. The free (top left) and total VP data (bottom left) demonstrated up to a 400% reduction in free and total VPs when the BIOFILM was applied before smoke-exposure. Box-whisker plots (right) highlight the observed differences at commercial maturity (t5). Similar results were observed for other VPs evaluated at vineyard 3. Bar graph data are shown as the mean ±1 SEM. For box-whisker plots, center lines show medians, box limits indicate the 25th and 75th percentiles, whiskers extend to 1.5 times the interquartile range from the 25th and 75th percentiles and points beyond these ranges were assigned as outliers.

**The BIOFILM significantly reduced free and total VPs in treated grapes**

## Summary

- the synthetic biofilm shows promise for proactive protection of grapes during forest fire season
- OIL 1 may exacerbate the impact of forest fire smoke on grape quality
- future work will include a large-scale field trial to assess dose/timing of spray application and sensory analysis of wines made from treated grapes

## References & Acknowledgements

(1) Kennison, K. *et al. J. Agric. Food Chem.* **2007**, 55, 10897-10901.
(2) Hayasaka, Y, *et al. J. Agric. Food Chem.* **2013**, 61, 25–33.
(3) Noestheden, M. *et al. J. Agric. Food Chem.* **2018**, 66, 695-703.
(4) Noestheden, M. *et al. Food Chem.* **2018**, 259, 147-156.

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