Wildfire Ash: Impacts on Forage Crops

The Problem

The impacts of wildfire ash deposition on crops grazed or harvested for livestock feed were largely unknown, especially relative to burned structures containing unknown levels of contaminants from household products, vehicles, businesses and residential chemicals. Notable fires during the sampling period were the Carr, Mendocino Complex, and Camp Fires in Northern California.

The Study

During the fire season of 2018, we sampled:

✓ 26 irrigated pastures
✓ 20 hay stacks
✓ 15 corn silage piles

from locations throughout California, either affected or not affected by wildfire ash. All samples were analyzed for:

**Heavy Metals:**
- Copper
- Iron
- Manganese
- Molybdenum
- Zinc
- Cadmium
- Lead
- Mercury
- Arsenic

**Minerals:**
- Calcium
- Magnesium
- Phosphorus
- Potassium
- Sulfur

A subset of 37 samples were analyzed for chemical compounds by gas and liquid chromatography–mass spectrometry organic chemical screens. These screens detect a large number of organic compounds belonging to diverse chemical classes, including pesticides, environmental contaminants, drugs, and other natural products.
The Results

Compounds of interest that were detected in 6 of 37 forage samples included:

- Ethoprop (pasture, hay)
- Caffeine (pasture)
- Linalool (hay)
- 1H-pyrrole-2'5-dione (hay)
- Acetamiprid (silage)

Detection of these compounds was not associated with forage type or geographic location. It is possible that some chemicals could have been detected due to naturally occurring plant compounds or legacy chemicals.

Lead, mercury, arsenic and cadmium were not detected in any samples. Copper, manganese, zinc, iron, and molybdenum were detected in some samples, with most levels below the maximum tolerable limit (MTL) for cattle as published in *Mineral Tolerance of Animals* (NRC 2005; Table 1).

<table>
<thead>
<tr>
<th>Metal</th>
<th>Range (ppm)</th>
<th>Median (ppm)</th>
<th>Mean (ppm)</th>
<th>Dietary Maximum Tolerable Level for Cattle (ppm)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>1.4 - 86</td>
<td>4.25</td>
<td>8.5</td>
<td>40²</td>
</tr>
<tr>
<td>Manganese</td>
<td>3.8 - 500</td>
<td>23.0</td>
<td>40.8</td>
<td>2,000</td>
</tr>
<tr>
<td>Zinc</td>
<td>4.8 – 65</td>
<td>9.6</td>
<td>14.2</td>
<td>500</td>
</tr>
<tr>
<td>Iron</td>
<td>14 – 1,900</td>
<td>81.0</td>
<td>158.3</td>
<td>500</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0 – 2.8</td>
<td>0</td>
<td>0.25</td>
<td>5</td>
</tr>
</tbody>
</table>

¹ Maximum tolerable levels are for cattle on a dry matter basis. Consult the appropriate section of NRC (2005) for additional considerations.
² Dietary maximum tolerable level for sheep is 15 mg Cu/kg dry matter.

To determine the effects of heavy metal levels, we conducted an analysis of variance using factors of forage source (pasture, hay, silage), presence of ash (Yes or No), and their interaction. There was a tendency for copper to vary by forage type ($P = 0.07$) and it was higher in fields not affected by ash ($P = 0.03$). Zinc was affected by forage source ($P < 0.01$), but not by the presence of ash ($P = 0.32$). Manganese was significantly impacted by forage source ($P = 0.04$), but not by ash ($P = 0.12$). Iron was impacted by forage source ($P = 0.02$), but not by the presence of ash ($P = 0.19$). See Table 2, next page.
Minerals were detected at generally low levels across all forage types, with only potassium detected at higher levels in several samples (Table 3).

**Table 2: Metal Concentrations by Forage Source and Presence of Wildfire Ash**

<table>
<thead>
<tr>
<th>Forage Source</th>
<th>Copper (ppm)</th>
<th>Zinc (ppm)</th>
<th>Manganese (ppm)</th>
<th>Iron (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>4.4 a¹</td>
<td>12.3 a</td>
<td>62.8 b</td>
<td>94 a</td>
</tr>
<tr>
<td>Silage</td>
<td>15.1 b</td>
<td>10.1 a</td>
<td>12.9 a</td>
<td>80.9 a</td>
</tr>
<tr>
<td>Hay</td>
<td>7.7 ab</td>
<td>21.9 b</td>
<td>54.0 b</td>
<td>291 b</td>
</tr>
<tr>
<td>Presence of Ash (Yes/No)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>4.9 a</td>
<td>13.6 a</td>
<td>30.6 a</td>
<td>199.0 a</td>
</tr>
<tr>
<td>No</td>
<td>13.2 b</td>
<td>15.9 a</td>
<td>55.9 a</td>
<td>111.5 a</td>
</tr>
</tbody>
</table>

¹Within a column, concentrations with the same letter are not different at $P = 0.05$.

**Table 3: Mineral Concentrations**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Range (%)</th>
<th>Median (%)</th>
<th>Mean (%)</th>
<th>Dietary Maximum Tolerable Level for Cattle (%)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>0.15 – 1.4</td>
<td>0.37</td>
<td>0.49</td>
<td>1.5</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.1 – 0.45</td>
<td>0.22</td>
<td>0.22</td>
<td>0.7</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.09 – 0.43</td>
<td>0.25</td>
<td>0.25</td>
<td>0.6</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.26 – 3.58</td>
<td>1.71</td>
<td>1.68</td>
<td>2.0</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.09 – 0.44</td>
<td>0.19</td>
<td>0.20</td>
<td>0.4</td>
</tr>
</tbody>
</table>

¹ Maximum tolerable levels are for cattle on a dry matter basis. Consult the appropriate section of NRC (2005) for additional considerations.

**The Take Home**

Though there were some compounds of interest and a few high levels of heavy metals detected in our samples, results were generally unremarkable and did not suggest that wildfire ash was consistently associated with heavy metals in forages. The positive samples were randomly distributed and not all from areas affected by wildfire ash. While more detailed and controlled studies could provide additional information, these results indicate that forages affected by wildfire ash deposition are likely safe for livestock to consume.

If you have forages that may be affected by ash deposition, evaluate the concentrations of minerals before formulating a ration. If you’re exceptionally concerned about toxicity from contamination and cannot dilute with unaffected feed, isolate and test feed for heavy metals and organic compounds. Reach out to your local UCCE Farm Advisor if you have questions regarding taking a representative sample, choosing a lab, lab analyses, or interpreting your results.
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The Team

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References


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