Environmental Fate of Herbicides

J. Ferrell
Extension Weed Specialist
What is Environmental Fate?

• Simple definition: what happens to the herbicide after it leaves the sprayer.
Why does it matter?

• We want to kill weeds.

• We don’t want to
  – Contaminate groundwater
  – Sterilization of water or soil
  – Create a “public concern”
Fate of a Herbicide

- Persistence
- Degradation
- Mobility
Herbicide Persistence

• How long a herbicide stays intact in the environment.

• Long Persistence
  – Good for weed control
  – Not good for the environment. The longer it persists, the more likely it is to move off site.
Persistence

- How long do herbicides persist
  - Depends on the properties of the herbicide

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Half-life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td>10</td>
</tr>
<tr>
<td>Aminopyralid (Milestone VM)</td>
<td>28</td>
</tr>
<tr>
<td>Picloram (Tordon)</td>
<td>90</td>
</tr>
<tr>
<td>Bromacil (Hyvar, Krovar)</td>
<td>150</td>
</tr>
</tbody>
</table>
Small changes can make big differences

Picloram – half-life 90 days  
(Tordon)

Aminopyralid – half-life 30 days  
(Milestone VM)
Dissipation

• The herbicide is broken down and no longer possess herbicidal activity
• Processes include:
  – Microbial – deactivated by soil microbes
  – Hydrolysis – reaction with water
  – Photolysis – deactivated by light
atrazine
Atrazine: Common Metabolites

Atrazine

Hydrolysis

Hydroxyatrazine
Atrazine: Common Metabolites

Atrazine → Hydroxyatrazine (Microbial)

Atrazine → De-ethylatrazine (Hydrolysis)

Atrazine → De-isopropylatrazine
Dissipation

• The herbicide is broken down and no longer possess herbicidal activity
• Processes include:
  – Microbial – deactivated by soil microbes
  – Hydrolysis – reaction with water
  – Photolysis – deactivated by light
• Given time, the molecule becomes CO$_2$
Photolysis

• Herbicide broken down by light

• This is why fluridone (Sonar) will persist longer in muddy water.
Herbicide Mobility - Off-site movement

- If degradation is slow, the more opportunity the herbicide will move off-site
  - Runoff – surface water contamination
  - Leaching – ground water contamination
  - Volatility – non-target injury
Runoff – Lateral Movement
Swath of Death
Lateral movement is bad

Why did this happen? They sprayed a off-label herbicide that is highly persistent and mobile.
Which herbicides are most likely to move?

• Hexaxinone (Velpar) – beware of spraying on back slopes. Some trees are very sensitive.

• Bromacil (Hyvar/Krovar) – can easily move

• Imazapyr – movement is not common, but it is very persistent. A misapplication may cause problems.
Leaching

• Leaching is when a herbicide moves deep into the soil.

• Why would a herbicide leach?
  – Low clay and organic matter content in soil
  – Highly water soluble herbicide
  – Doesn’t bind tightly to soil
  – Long soil persistence
Herbicide adsorption

Organic matter

- - - - -
clay

herbicide +

herbicide -

+ +

- -
Herbicide adsorption

Herbicide

Sand
Neutral charge
Leaching also depends on the herbicide

Picloram – no charges, hardly binds to clay or organic matter. Persists for a LONG time. Leaching is common.

Can not be used in Florida.

Diquat – strong positive charges, binds tightly to almost anything. Leaching is impossible.

Commonly used in Florida.
Leaching

• Leaching is likely when:
  – herbicide has long soil persistence
  – Herbicide does not bind tightly to soil
    • Soil with high sand - low clay
## Volatility

- How likely the herbicide will turn to gas

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Vapor pressure (mm Hg)</th>
<th>Relative Volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluridone (Sonar, etc.)</td>
<td>$1 \times 10^{-7}$</td>
<td>Very low</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>$1 \times 10^{-7}$</td>
<td>Very low</td>
</tr>
<tr>
<td>Imazapyr (Habitat, etc)</td>
<td>$2 \times 10^{-7}$</td>
<td>Very low</td>
</tr>
<tr>
<td>Triclopyr amine (Garlon 3A)</td>
<td>$3 \times 10^{-7}$</td>
<td>Very low</td>
</tr>
<tr>
<td>Triclopyr ester (Garlon 4)</td>
<td>$3 \times 10^{-6}$</td>
<td>Low</td>
</tr>
<tr>
<td>2,4-D amine</td>
<td>$8 \times 10^{-6}$</td>
<td>Low</td>
</tr>
<tr>
<td>2,4-D ester</td>
<td>$1 \times 10^{-2}$</td>
<td>Very high</td>
</tr>
<tr>
<td>Dicamba (Veteran)</td>
<td>$9 \times 10^{-6}$</td>
<td>Low</td>
</tr>
</tbody>
</table>
Conclusion

• Herbicide fate
  – persist,
  – move off site, or
  – degrade in the environment.
Conclusions

• Degradation of a herbicide in the environment occurs by microbes, light, or chemical reactions in the water.
• Most of the herbicides we use today have a relatively short life in the environment.
• If they are found to persist too long, they will not be granted registration by EPA.