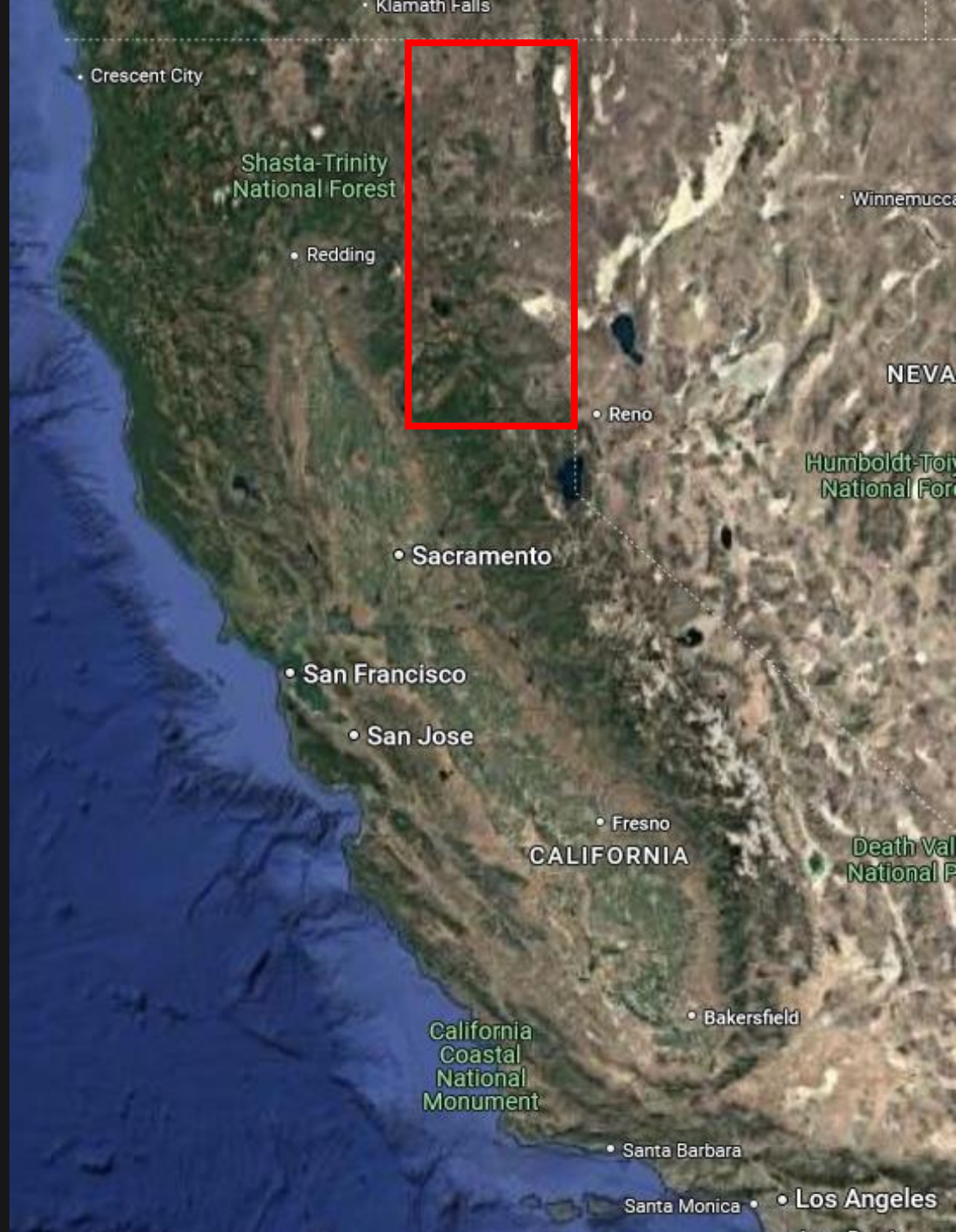
Understanding Herbicides

UCCE Farm Advisor: Tom Getts
Lassen, Modoc, Sierra, and Plumas Counties

University of California
Agriculture and Natural Resources

Tom Getts

- UC Extension
- Weed Ecology and Cropping Systems Advisor
  - Lassen
  - Modoc
  - Sierra
  - Plumas
- Invasive Weeds
- Agronomic Pests



Outline

- Toxicity
- Labels
- Herbicide Basics Definitions
  - Selectivity
  - Pre vs Post
  - Contact Vs Systemic
- Type of Herbicides and When to Use
  - Organic herbicides
  - Conventional herbicides
- Labels!
- Application types
- Minimizing off target risk!
- Resistance

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What are herbicides?

- Products used to kill Plants

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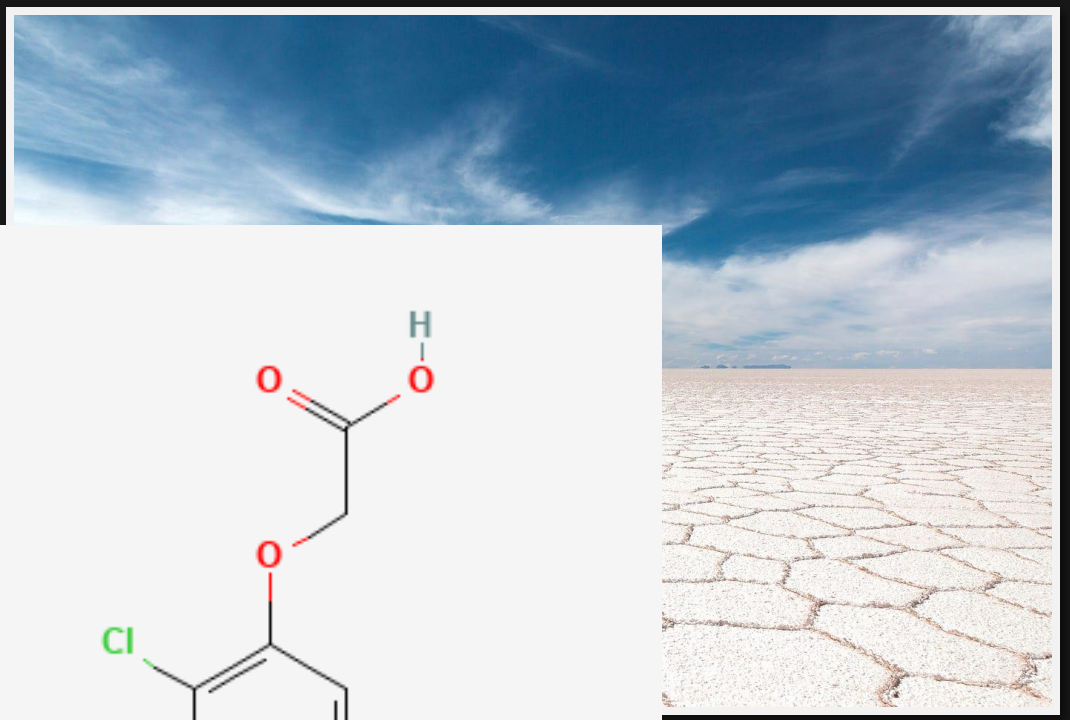
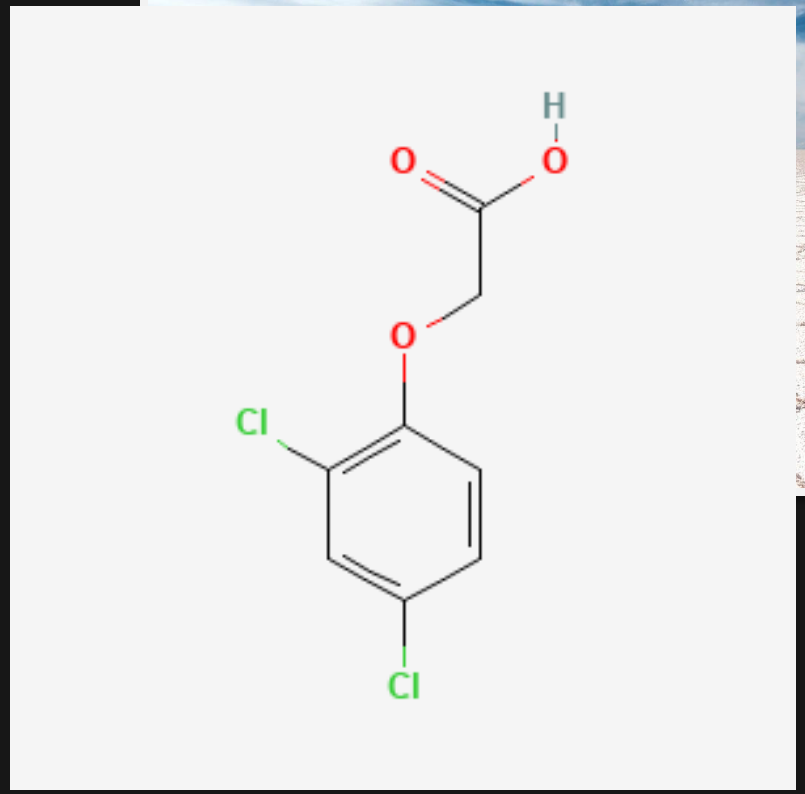
- “Salt the field of enemies”

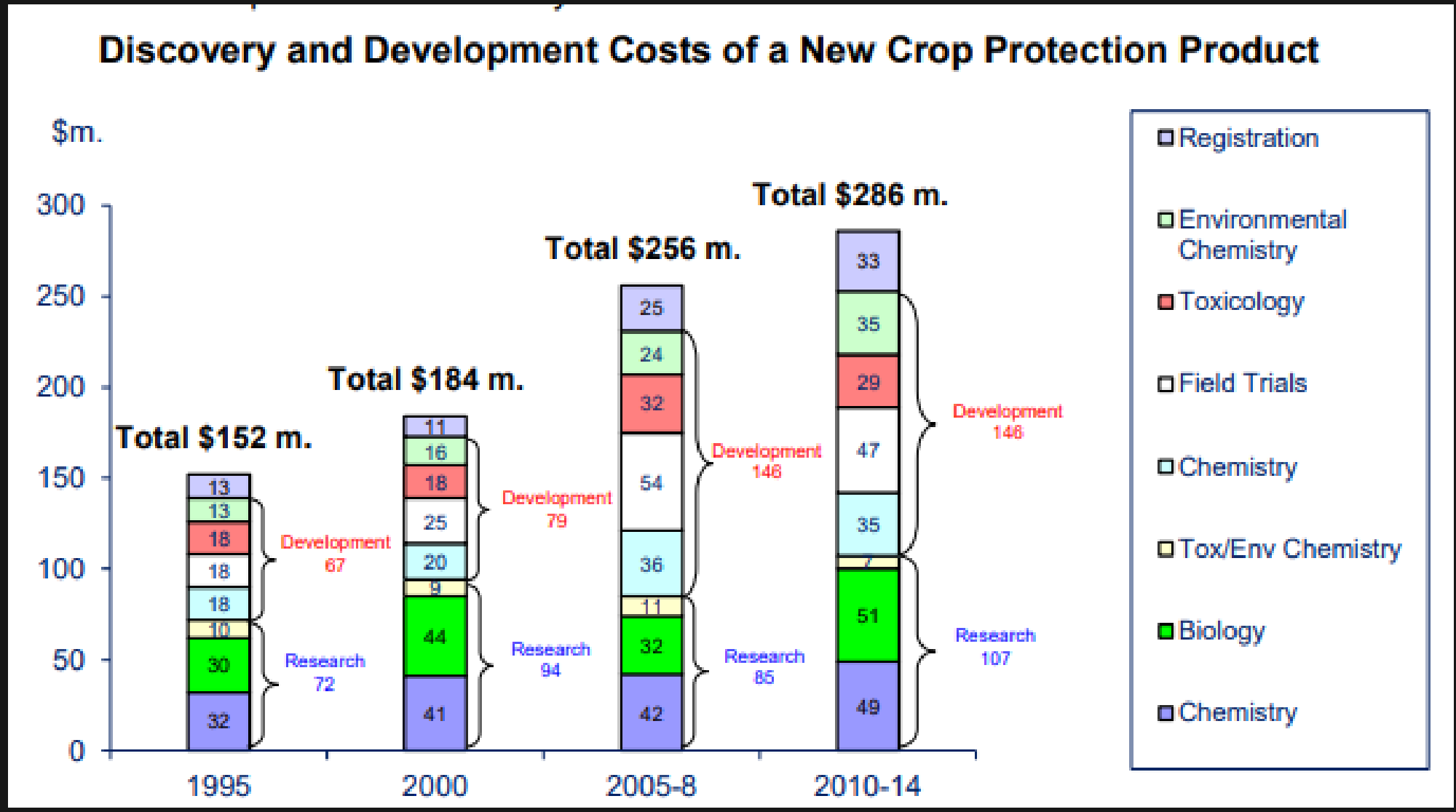
- 2,4-D- WW2
- 258ish Synthetic herbicides today





Pesticides are Regulated Materials!

- Early Laws- Products that Work
- Later Laws- Environmental Protection
- Extensive Registration Process
  - EPA
  - DPR



Cost- Phillips McDougall 2016

EPA Process Regulation!

- Registration
  - Studies-submitted to the EPA by registrant
  - Ecological risk Assessment
    - Risk assessment of likely harmfully effects
      - Wildlife Ecology
      - Population Dynamics
      - Physiology
      - Environmental Chemistry
      - Water
  - Human Health Assessment
    - Food, Water, Air, Work Etc.- Needs to meet safety standards
      - Toxicology
      - Dose Response-
      - How much exposure- Food/drinking water
      - Risk Characterization
      - RISK = TOXICITY x EXPOSURE
- Then in CA DPR!

Label is the Law!

- Federal Crime to use a pesticide Off Label
- **Read and Follow the Label!**
- Millions Dollars Research into Labels
  - Protect users
  - Protect the environment
  - All based on science
  - EPA is typically considered conservative

Pesticides!

Acute Toxicity and Signal words

- **CAUTION** means the pesticide product is slightly toxic if eaten, absorbed through the skin, inhaled, or it causes slight eye or skin irritation

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Acute Toxicity and Signal words

- **CAUTION** means the pesticide product is slightly toxic if eaten, absorbed through the skin, inhaled, or it causes slight eye or skin irritation
- **WARNING** indicates the pesticide product is moderately toxic if eaten, absorbed through the skin, inhaled, or it causes moderate eye or skin irritation.
- **DANGER** means that the pesticide product is highly toxic by at least one route of exposure. It may be corrosive, causing irreversible damage to the skin or eyes. Alternatively, it may be highly toxic if eaten, absorbed through the skin, or inhaled. If this is the case, then the word "POISON" must also be included in red letters on the front panel of the product label.

- Definitions taken from the National Pesticide Information Center
- http://npic.orst.edu/factsheets/signalwords.html

npic NATIONAL PESTICIDE INFORMATION CENTER

1.800.858.7378 npic@oregonstate.ed
We're open from 8:00AM to 12:00PM Pacific Time, Mon-F
A to

About Us | Health | Environment | Pest Information | Product/Chemical Info | Emergency | Search...

NEW FACT SHEET

Bacillus thuringiensis (Bt) in Genetically Modifi

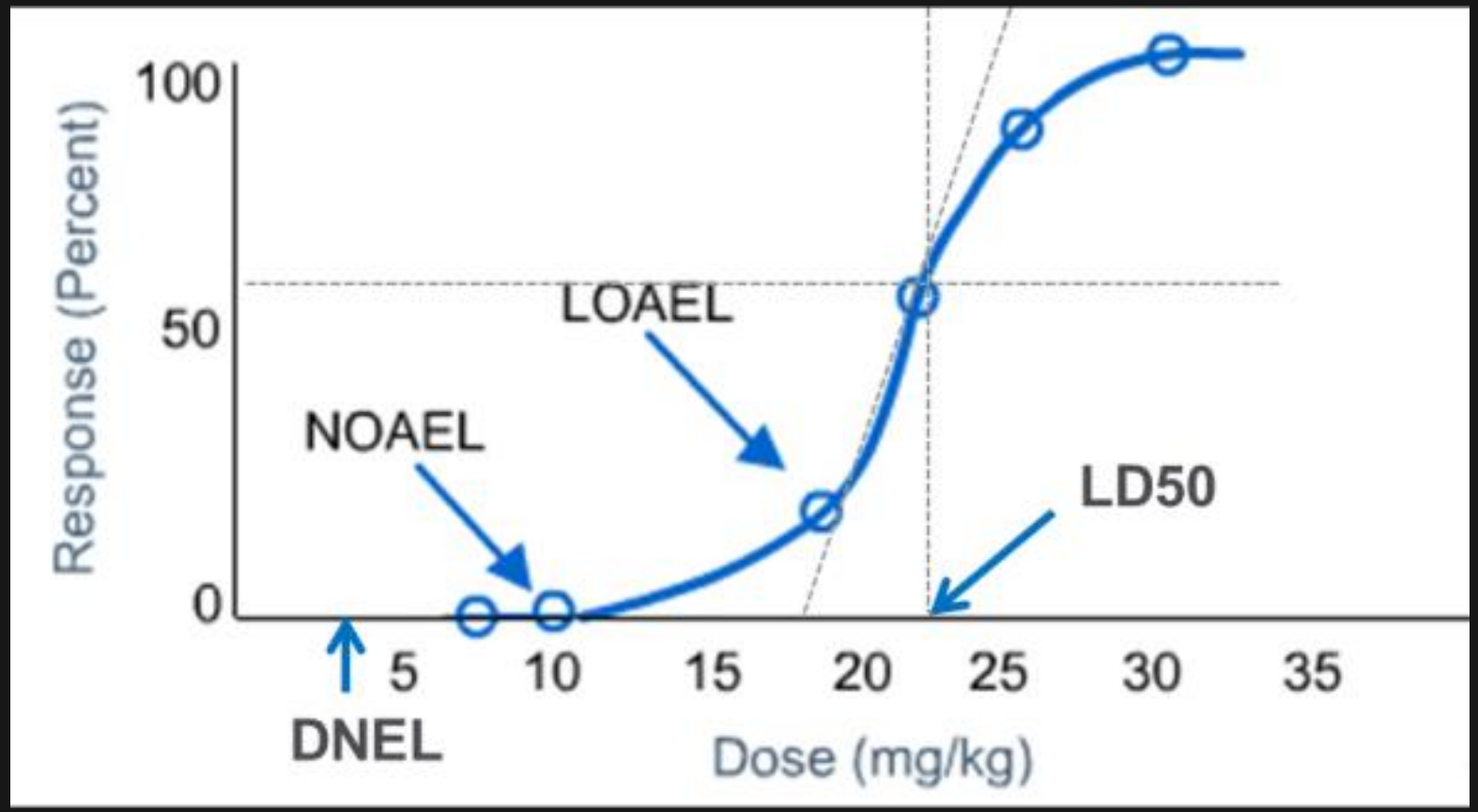
Chat now

	TOXICITY CATEGORY (Signal Word)[2]			
	High Toxicity (DANGER/Danger-Poison) Category I	Moderate Toxicity (WARNING) Category II	Low Toxicity (CAUTION) Category III	Very Low Toxicity (Optional Signal Word = CAUTION) Category IV
Acute Oral LD_{50}	Up to and including 50 mg/kg (≤ 50 mg/kg)	Greater than 50 through 500 mg/kg (>50-500 mg/kg)	Greater than 500 through 5000 mg/kg (>500-5000 mg/kg)	Greater than 5000 mg/kg (>5000 mg/kg)
Inhalation LC_{50}	Up to and including 0.05 mg/L (≤0.05 mg/L)	Greater than 0.05 through 0.5 mg/L (>0.05-0.5 mg/L)	Greater than 0.5 through 2.0 mg/L (>0.5-2.0 mg/L)	Greater than 2.0 mg/L (>2.0 mg/L)
Dermal LD_{50}	Up to and including 200 mg/kg (≤200 mg/kg)	Greater than 200 through 2000 mg/kg (>200-2000 mg/kg)	Greater than 2000 through 5000 mg/kg (>2000-5000 mg/kg)	Greater than 5000 mg/kg (>5000 mg/kg)
Primary Eye Irritation	Corrosive (irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days	Corneal involvement or other eye irritation clearing in 8 - 21 days	Corneal involvement or other eye irritation clearing in 7 days or less	Minimal effects clearing in less than 24 hours
Primary Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring)	Severe irritation at 72 hours (severe erythema or edema)	Moderate irritation at 72 hours (moderate erythema)	Mild or slight irritation at 72 hours (no irritation or erythema)

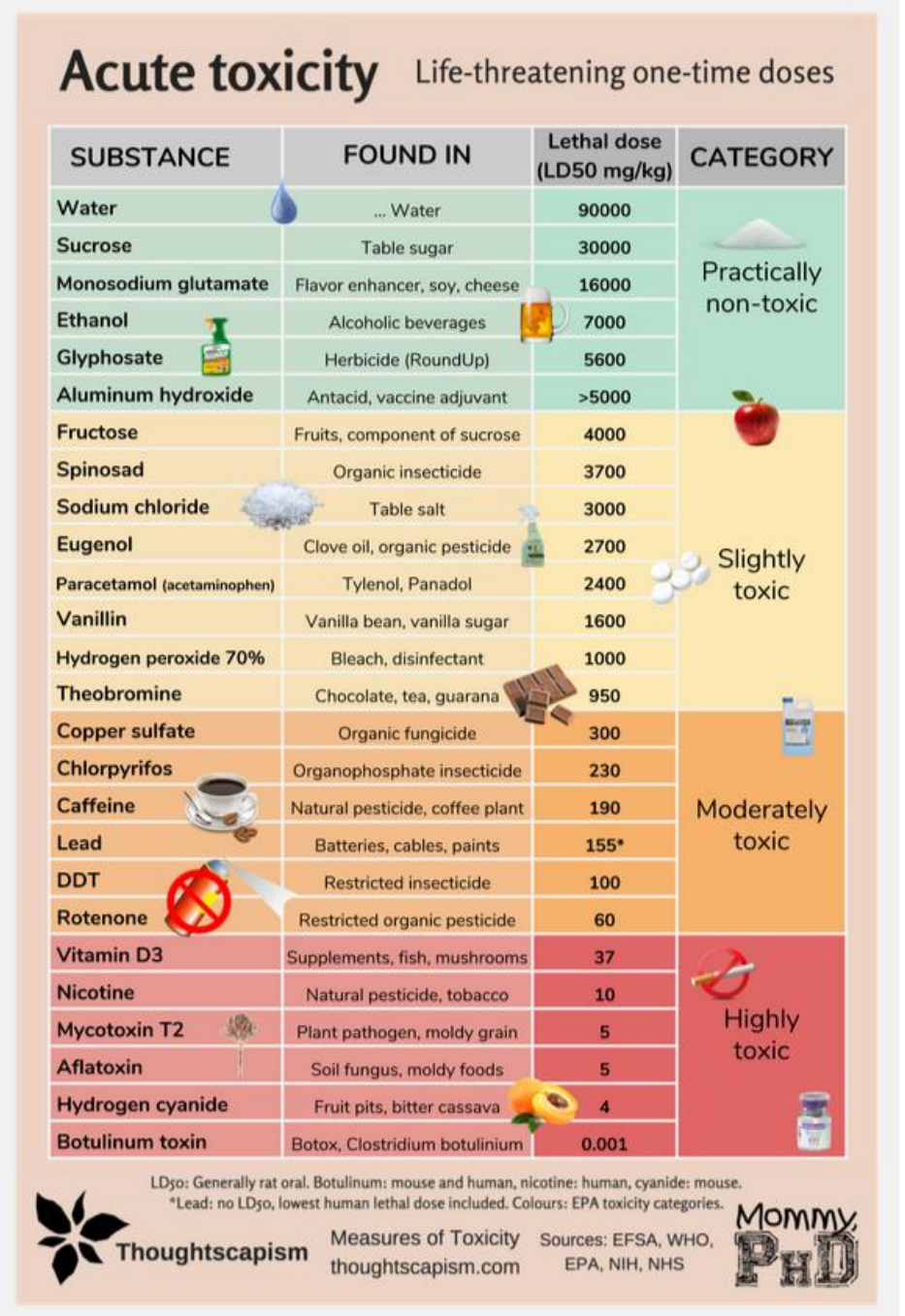
Courtesy of NPIC.org

LD/50

- Lethal Dose To kill 50 % of a population.
  - Weight of Material
  - Weight of Animal
- X mg/kg herbicide to kill 50% of a population
- Acute toxicity



Courtesy of chemsafetypro.com



Acute toxicity

Life-threatening one-time doses

SUBSTANCE	FOUND IN	Lethal dose (LD50 mg/kg)	CATEGORY
Water	... Water	90000	Practically non-toxic
Sucrose	Table sugar	30000	
Monosodium glutamate	Flavor enhancer, soy, cheese	16000	
Ethanol	Alcoholic beverages	7000	
Glyphosate	Herbicide (RoundUp)	5600	
Aluminum hydroxide	Antacid, vaccine adjuvant	>5000	
Fructose	Fruits, component of sucrose	4000	Slightly toxic
Spinosad	Organic insecticide	3700	
Sodium chloride	Table salt	3000	
Eugenol	Clove oil, organic pesticide	2700	
Paracetamol (acetaminophen)	Tylenol, Panadol	2400	
Vanillin	Vanilla bean, vanilla sugar	1600	
Hydrogen peroxide 70%	Bleach, disinfectant	1000	
Theobromine	Chocolate, tea, guarana	950	
Copper sulfate	Organic fungicide	300	Moderately toxic
Chlorpyrifos	Organophosphate insecticide	230	
Caffeine	Natural pesticide, coffee plant	190	
Lead	Batteries, cables, paints	155*	
DDT	Restricted insecticide	100	
Rotenone	Restricted organic pesticide	60	
Vitamin D3	Supplements, fish, mushrooms	37	Highly toxic
Nicotine	Natural pesticide, tobacco	10	
Mycotoxin T2	Plant pathogen, moldy grain	5	
Aflatoxin	Soil fungus, moldy foods	5	
Hydrogen cyanide	Fruit pits, bitter cassava	4	
Botulinum toxin	Botox, Clostridium botulinium	0.001	

LD_{50}: Generally rat oral. Botulinum: mouse and human, nicotine: human, cyanide: mouse.
*Lead: no LD_{50}, lowest human lethal dose included. Colours: EPA toxicity categories.

Thoughtscapism

Measures of Toxicity
thoughtscapism.com

Sources: EFSA, WHO, EPA, NIH, NHS

Mommy PhD

- 75 kg Human (165 lb's)
- 1 gram=1000mg
- 28.53 grams= 1 oz

- Sugar-2250 Grams
- Glyphosate-420 grams
- Table Salt- 225 Grams
- Caffeine-14 grams
- Nicotine-0.75 grams
- Botox-.000075 grams


REFILL
KILLS & PREVENTS UP TO 12 MONTHS
Roundup
READY-TO-USE
MAX CONTROL
365
KILLS THE ROOTS GUARANTEED*
KILLS VEGETATION FOR UP TO 12 MONTHS
FOR USE ON DRIVEWAYS, PATIOS, SIDEWALKS AND GRAVEL AREAS
NET 1.25 GAL (160 FL OZ/ 4.73L)
Keep Out of Reach of Children
CAUTION
See back panel booklet for additional precautionary statements.
Mantener Fuera del Alcance de los Niños
PRECAUCIÓN
Vea los avisos adicionales de precaución en el panel posterior.
ACTIVE INGREDIENTS:
Glyphosate, isopropylamine salt* ... 1.00%
Imazapic, ammonium salt** ... 0.08%
Diquat dibromide ... 0.04%
OTHER INGREDIENTS ... 98.88%
TOTAL 100.00%
*Contains 0.06 lb. glyphosate acid equivalent and **0.006 lb. imazapic acid equivalent per US gallon.


Hi-Yield
Grass Killer
Postemergence Grass Herbicide
• Systematic Selective Herbicide Kills Weedy Grasses Without Injuring Desirable Plants.
• Controls: Bermudagrass, Crabgrass, Foxtails, Quackgrass And many other Weedy Grasses.
• Concentrate Makes 8 Gallons of Spray Solution.
ACTIVE INGREDIENT:
Sethoxydim: 2-[1(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one* ... 18.0%
OTHER INGREDIENTS: ... 82.0%
TOTAL: ... 100.0%
*Equivalent to 1.5 lbs sethoxydim per gallon.
KEEP OUT OF REACH OF CHILDREN
WARNING
See The Attached Booklet For Complete Precautionary Statements, Directions For Use, First Aid, Conditions Of Sale And Warranty, and state-specific crop and/or use site restrictions.
NET CONTENTS 8 Fl. Ozs.

PHARM SOLUTIONS, INC.

WEED PHARM

For Organic Production

WEED & GRASS KILLER

1 gal.
Ready-to-Use

A HORTICULTURAL BIOPESTICIDE

For non-selective control of herbaceous broadleaf weeds and weed grasses which surround food crops, non-food crops and non-production agricultural, farmstead, right-of-way, and institutional land sites.

KEEP OUT OF REACH OF CHILDREN
DANGER - PELIGRO

Si usted no etiquets, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

EPA Registration No. 81936-1-81935
EPA Establishment No. 85804-NC-001
Batch Code:_____

Pharm Solutions, Inc.
2023 E. Sims Way, Suite 358
Port Townsend, WA 98368
www.pharmsolutions.com

Active Ingredients by Wt.

Acetic Acid	20.0%*
Other Ingredients	80.0%
Total	100%

*Equivalent to 200 grain vinegar by filtration

FIRST AID

IF IN EYES:
Hold eyelids open and flush with a steady, gentle stream of water for 15-20 minutes.

Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.

Call a poison control center or doctor for advice.

IF ON SKIN OR CLOTHING:
Take off contaminated clothing.

Rinse skin immediately with plenty of water for 15-20 minutes.

Call a poison control center or doctor for further treatment advice.

IF SWALLOWED:

Call a poison control center or doctor immediately for treatment advice.

FIRST AID CONT'D
Have person sip a glass of water if able to swallow.

Do not induce vomiting unless told to do so by poison control center or doctor.

Do not give anything by mouth to an unconscious person.

IF INHALED:

Move person to fresh air.

If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible.

Call a poison control center or doctor for further treatment advice.

NOTE TO PHYSICIAN: Probable mucosal damage may contra-indicate the use of gastric lavage.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-858-7378 for emergency medical treatment.

See label back panel for additional precautionary statements.

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

DANGER: Corrosive - causes irreversible eye damage. Wear goggles or face shield when handling. Harmful if absorbed through skin. Harmful if swallowed. Do not get in eyes, on skin, or on clothing. In case of contact, immediately flush eyes or skin with plenty of water. Get medical attention if irritation persists. Wash thoroughly with soap and water after handling. Wear personal protection equipment when handling and/or applying.

PERSONAL PROTECTION EQUIPMENT (PPE): Applicators and other handlers must wear appropriate protective eyewear, such as face shield or goggles, and face mask (with MSHA/NIOSH approval number prefix such as N-95, R-95, or P-95), long sleeved shirt and long pants, waterproof gloves and shoes plus socks.

DonnaThomas

50% VINEGAR, BEST QUALITY

Reviewed in the United States on April 23, 2025

Size: 128 Ounce (Pack of 2) | Verified Purchase

tHIS WORKS VERY WELL FOR CLEANING AND MOST OF ALL WEEDS AND SAFE FOR PETS.

One person found this helpful

Helpful | Report

Amazon Customer

Highly effective weed killer.

Reviewed in the United States on April 23, 2025

Size: 128 Ounce (Pack of 2) | Verified Purchase

I used this product for weed killing. It was mixed with water and epsom salts. I diluted it according to the instructions on the bottle and it has worked great. It is highly effective in killing all types of unwanted growth. Further it is much cheaper then premixed week killers.

10 people found this helpful

Helpful | Report

calvin brugge

Maybe deluited by 2 ÷ 10

Reviewed in the United States on April 26, 2025

Size: 128 Ounce (Pack of 2) | Verified Purchase

This item combined with 2 cups of salt and 2 tablespoons of dish washing liquid.
Creates an powerful weed & shrub killer
Non toxic, non cancerious
Strong reaction on weed.

17 people found this helpful

Helpful | Report

See more reviews

IN THIS ARTICLE

PHOTO: The Spruce

$35 at Amazon

$44 at Walmart

$35 at Home Depot

What We Like

- Contains no harsh chemicals
- Safe for pets and kids once dry
- No dilution needed
- Quick results

What We Don't Like

- Trigger can stick between squeezes
- Very strong vinegar odor
- Not rain resistant

ew History Bookmarks Tools Help

Organic Herbicides | Introduction to Pesticide | The 9 Best Weed Killers, | Amazon.com: Spectracid | Amazon.com: Green Gol | Roundup Weed and Gra | roundup weed and gras

https://ww

the spruce
Make your best home

Search

Toxicity/PPE

- **Read the label!**

- Dose And Exposure!
- Personal Protective Equipment!
  - Gloves
  - Long Shirt
  - Pants
  - Eye Ware
  - And more!
- **Acetic Acid**
  - Respirator
  - Face Sheild
  - Coveralls

- Step one
  - ID the Weed
  - Understand biology
    - Annual vs perennial
    - Seed life etc.
- Identify variety of tactics can be used to eliminate the weed/manage the population
- Mechanical, Physical, Biological, Cultural, Chemcial etc.

Choosing an herbicide?

- IPM
  - Do you even need a pesticide?

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  - Growth stage
  - Seed bank

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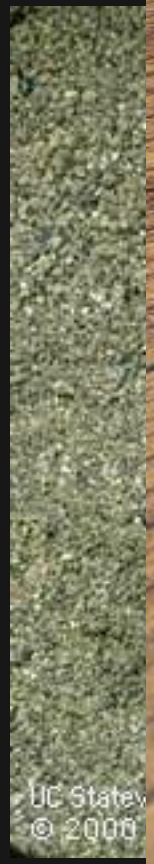

Choosing an herbicide?

- IPM
  - Do you even need a pesticide?
- Target Species!
  - Growth stage
  - Seed bank
- Desirable Species?
- Site
  - Grass
  - Driveway
  - Vegetables
  - Flowerbed

Herbicide Basic Definitions!

Herbicide Selectivity

Not all Herbicides kill all Plants!

Controlling some plants

but not others.

Affected by

- Plant species
- Herbicide
- Application timing
- Growth stage (dormant applications)
- Etc.

Image courtesy of : gmandchemicalindustry9.wordpress.com

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Soil Activity

- Pre-Emergence
  - Seeds
  - Root uptake
- Post-Emergence
- Both!

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Contact vs. Systemic

Contact –

- Does not move through plant (Ex - Vinegar, Oils, Organics, Diquat, Pelargonic Acids)
- Coverage matters
- Only kills top growth
- Does not kill root!

Contact vs. Systemic

Systemic –

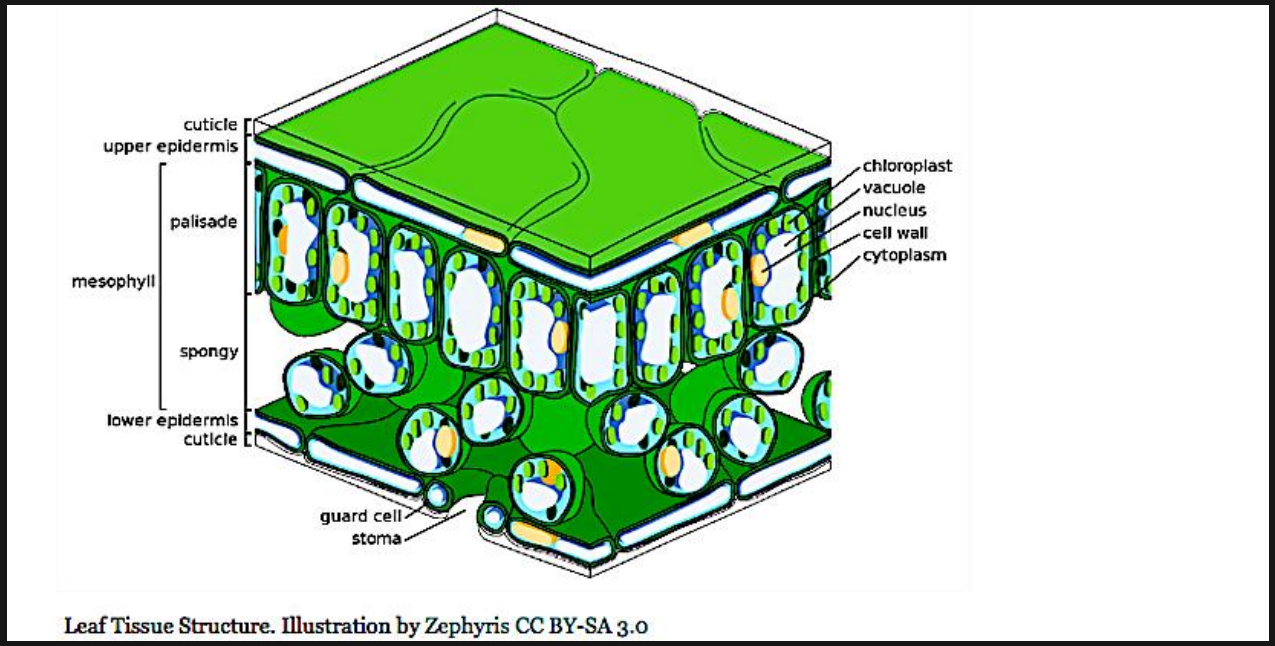
- Can move through plant (Ex – Roundup, 2,4-D, Imazapyr, Dicamba, Clethodim)
- Absorbed through leaf/stem/roots
- Can kill roots

Pre Emergent Herbicides

- Generally, kill seeds/keep them from germinating
- Need good coverage
  - Like “Blanket” over the soil
- Need incorporation
  - Rained into soil, or mixed-in with equipment.
  - Irrigation!
  - Applied fall or spring
  - Mid summer lack of rain limits effectiveness
- Some specific, some not specific
- Some stay in top of soil, some move….
  - Roots!

Post Emergent Herbicides

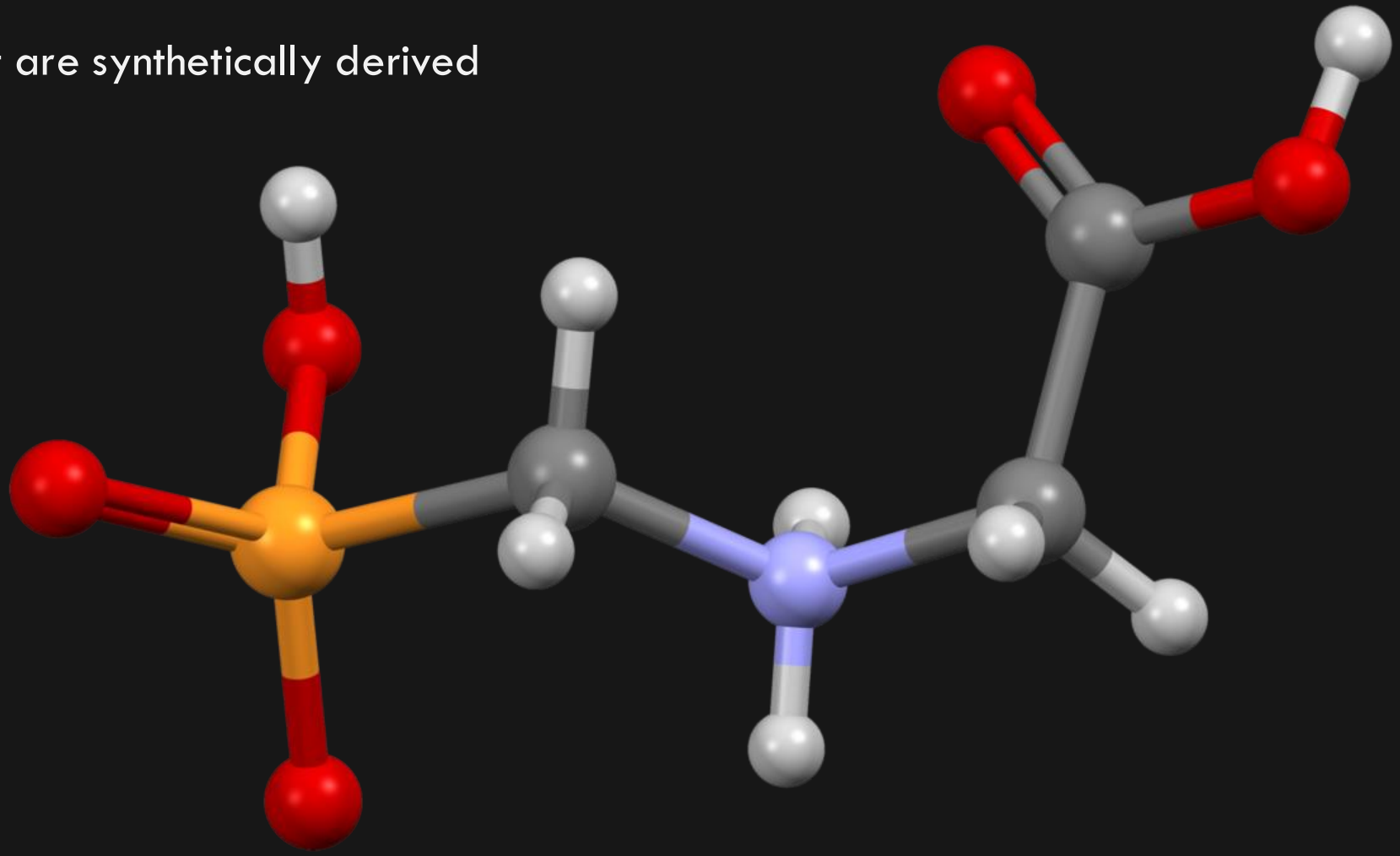
- Need green material
- Need to get through cuticle
- Coverage?
  - Systemic vs Contact
- Can be affected by weather
- Needs active growth
- Surfactants important
- Plant growth stage!



Leaf Tissue Structure. Illustration by Zephyris CC BY-SA 3.0

“Conventional” Herbicides

- Materials that are synthetically derived



Glyphosate

Mode of Action (MOA)

- How an herbicide physiologically works in the plant to kill the weed
- Approx 33 MOA's

Imag
http:

HERBICIDE RESISTANCE ACTION COMMITTEE

HRAC Mode of Action Classification 2024

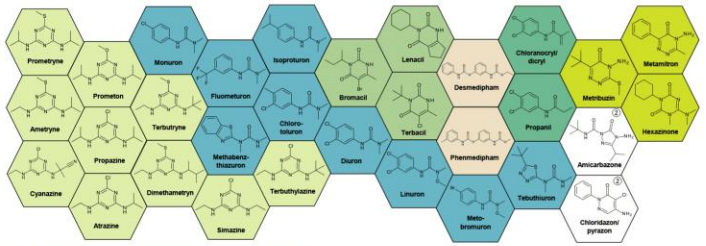
https://hracglobal.com/tools/2024-hrac-global-herbicide-moa-classification Here access the complete herbicide MoA classification excel database.

Light Activation of ROS[a]

5 Inhibition of Photosynthesis at PS II:

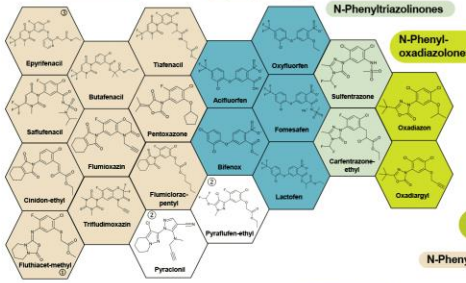
D1 Serine 264 binders (and other non-histidine 215 binders)

Triazines · Ureas · Uracils · Phenylcarbamates · Amides · Triazinones



14 Inhibition of Protoporphyrinogen Oxidase (PPO)

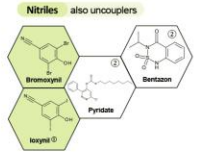
N-Phenylimides · Diphenyl ethers · N-Phenyltriazolinones · N-Phenyl-oxadiazolones



6 Inhibition of Photosynthesis at PS II:

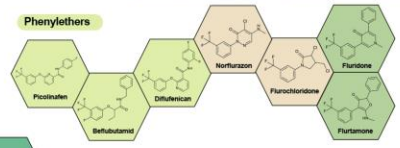
D1 Histidine 215 binders

Nitriles also uncouplers



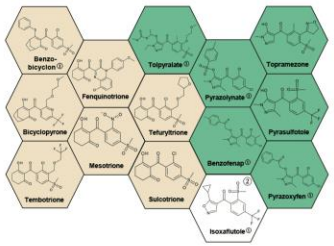
12 Inhibition of Phytoene Desaturase (PDS)

N-Phenyl heterocycles · Diphenyl heterocycles · Phenylethers



27 Inhibition of Hydroxyphenyl Pyruvate Dioxygenase (HPPD)

Triketones · Pyrazoles

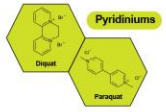


32 Inhibition of Solanesyl Diphosphate Synthase (SDPS)

33 Inhibition of Homogentisate Solanesyltransferase (HST)

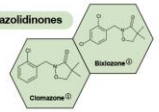
22 PS I Electron Diversion

Pyridiniums



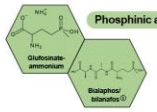
13 Inhibition of Deoxy-D-Xylulose Phosphate Synthase (DXPS)

Isoxazolidinones



10 Inhibition of Glutamine Synthetase (GS)

Phosphinic acids

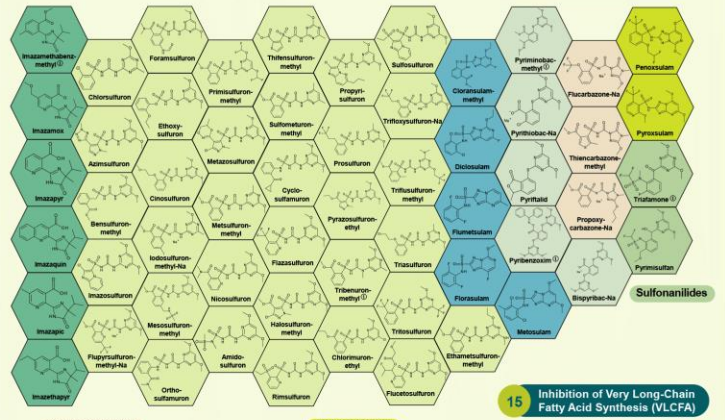


A free copy of this poster can be downloaded at www.hracglobal.com

Cellular Metabolism

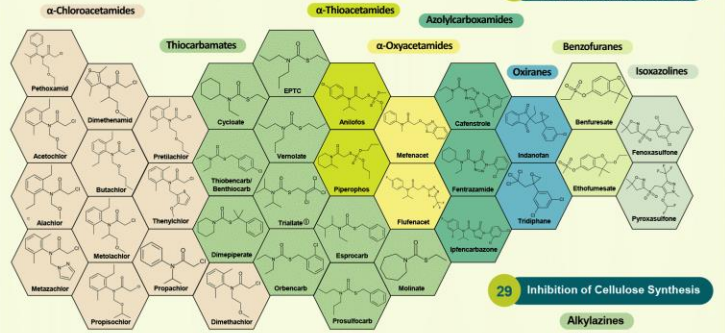
2 Inhibition of Acetolactate Synthase (ALS)

Pyrimidinylbenzoates · Triazolopyrimidine – type 2 · Imidazolinones · Sulfonylureas · Triazolopyrimidines – type 1 · Triazolinones · Sulfonanilides



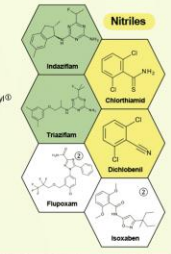
15 Inhibition of Very Long-Chain Fatty Acid Synthesis (VLCFA)

α-Chloroacetamides · α-Thioacetamides · Azolylcarboxamides · Thiocarbamates · α-Oxyacetamides · Benzofuranes · Oxiranes · Isoxazolines



29 Inhibition of Cellulose Synthesis

Alkylazines · Nitriles



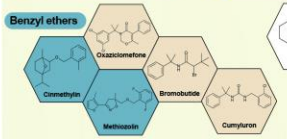
1 Inhibition of Acetyl CoA Carboxylase (ACCase)

Cyclohexanediones · Aryloxyphenoxypropionates

9 Inhibition of Enolpyruvyl Shikimate Phosphate Synthase (EPSPS)

30 Inhibition of Fatty Acid Thioesterase (FAT)

Benzyl ethers



31 Inhibition of Serine Threonine Protein Phosphatase (STPP)

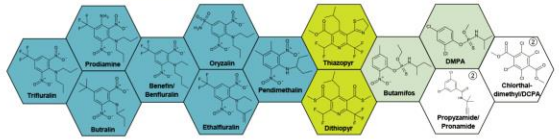
18 Inhibition of Dihydropteroate Synthase (DHPS)

28 Inhibition of Dihydroorotate Dehydrogenase (DHODH)

Cell Division and Growth

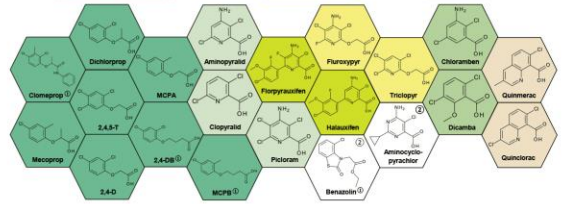
3 Inhibition of Microtubule Assembly

Dinitroanilines · Pyridines · Phosphoroamidates



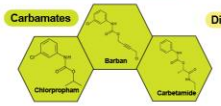
4 Auxin Mimics

6-Chloropicolinates · Pyridyloxycarboxylates · Quinolinecarboxylates · Phenoxycarboxylates · 6-Arylpicolinates · Benzoates



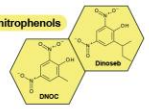
23 Inhibition of Microtubule Organization

Carbamates



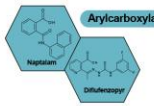
24 Uncouplers

Dinitrophenols



19 Auxin Transport Inhibitors

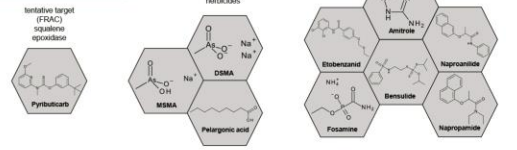
Arylcarboxylates



HRAC	Legacy HRAC	Mode of Action
1	A	Inhibition of Acetyl CoA Carboxylase (ACCase)
2	B	Inhibition of Acetolactate Synthase (ALS)
3	K1	Inhibition of microtubule assembly
4	O	Auxin mimics
5	C1,2	Inhibition of Photosynthesis at PS II - D1 Serine 264 binders (and other non-histidine 215 binders)
6	C3	Inhibition of Photosynthesis at PS II – D1 Histidine 215 binders
9	G	Inhibition of Enolpyruvyl Shikimate Phosphate Synthase (EPSPS)
10	H	Inhibition of Glutamine Synthetase (GS)
12	F1	Inhibition of Phytoene Desaturase (PDS)
13	F4	Inhibition of Deoxy-D-Xylulose Phosphate Synthase (DXPS)
14	E	Inhibition of Protoporphyrinogen Oxidase (PPO)
15	K3	Inhibition of Very Long-Chain Fatty Acid Synthesis (VLCFA)

HRAC	Legacy HRAC	Mode of Action
18	I	Inhibition of Dihydropteroate Synthase (DHPS)
19	P	Auxin transport inhibitors
22	D	PS I Electron Diversion
23	K2	Inhibition of microtubule organization
24	M	Uncouplers
27	F2	Inhibition of Hydroxyphenyl Pyruvate Dioxygenase (HPPD)
28	none	Inhibition of Dihydroorotate Dehydrogenase (DHODH)
29	L	Inhibition of cellulose synthesis
30	Q	Inhibition of Fatty Acid Thioesterase (FAT)
31	R	Inhibition of Serine Threonine Protein Phosphatase (STPP)
32	S	Inhibition of Solanesyl Diphosphate Synthase (SDPS)
33	T	Inhibition of Homogentisate Solanesyltransferase (HST)
Ø	Z	Unknown mode of action

Ø Unknown Mode of Action

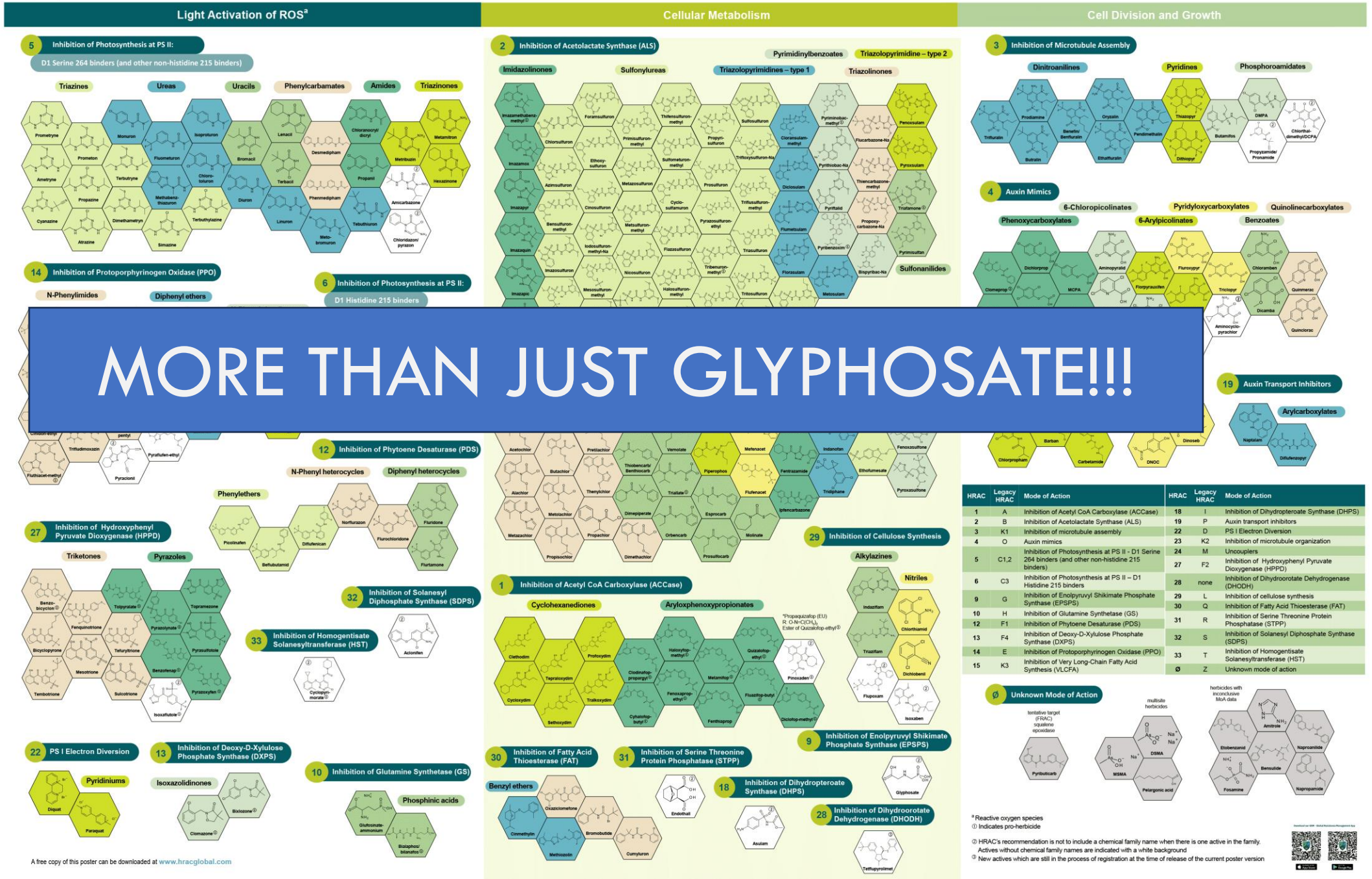


[a] Reactive oxygen species
① Indicates pro-herbicide

② HRAC's recommendation is not to include a chemical family name when there is one active in the family. Actives without chemical family names are indicated with a white background
③ New actives which are still in the process of registration at the time of release of the current poster version

Mode of Action (MOA)

- How an herbicide physiologically works in the plant to kill the weed
- Approx 33 MOA's



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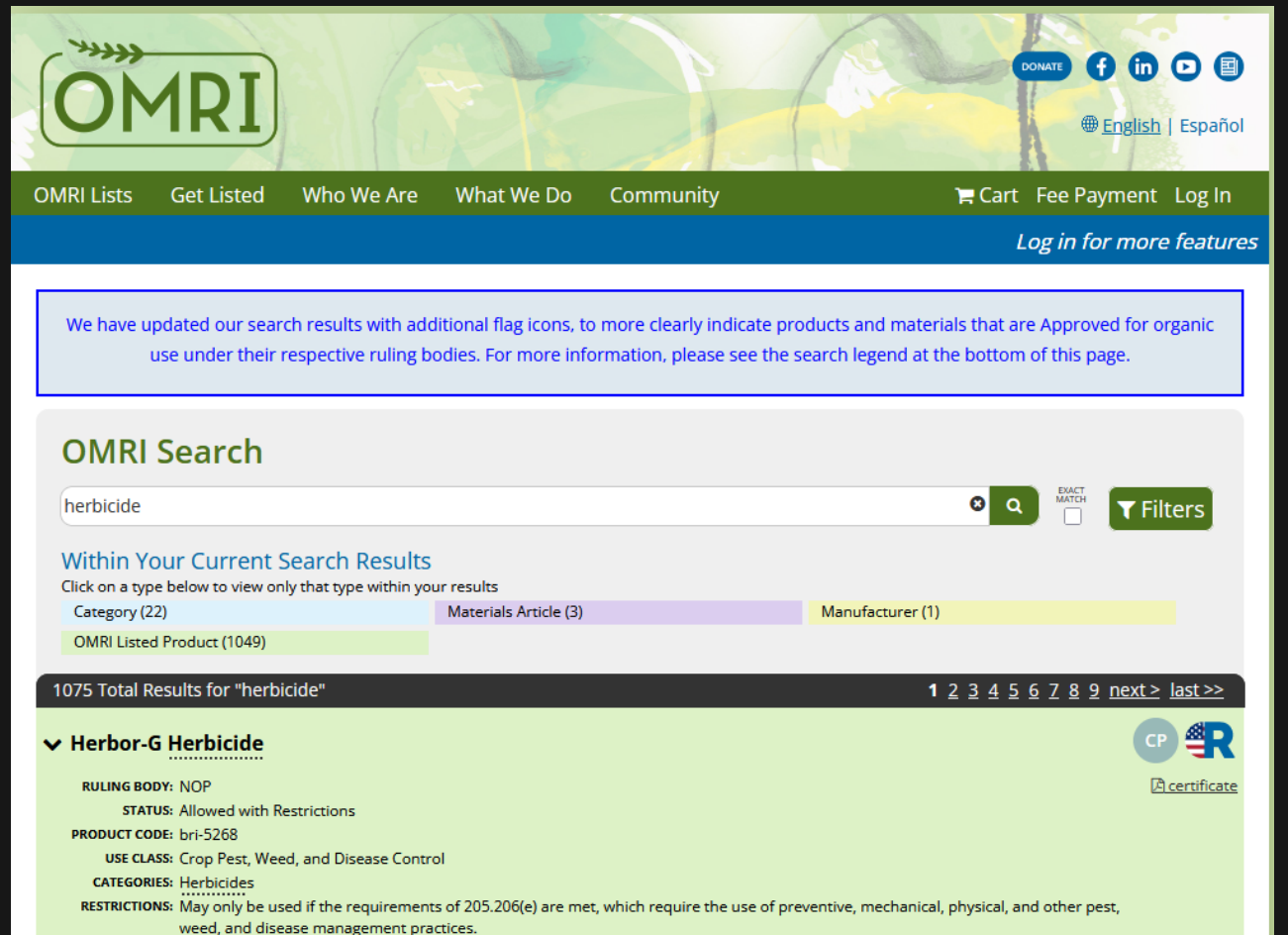
MORE THAN JUST GLYPHOSATE!!!

Imag
http:

Organic Herbicides

- "Organic herbicides are pesticides made of compounds that occur in nature"



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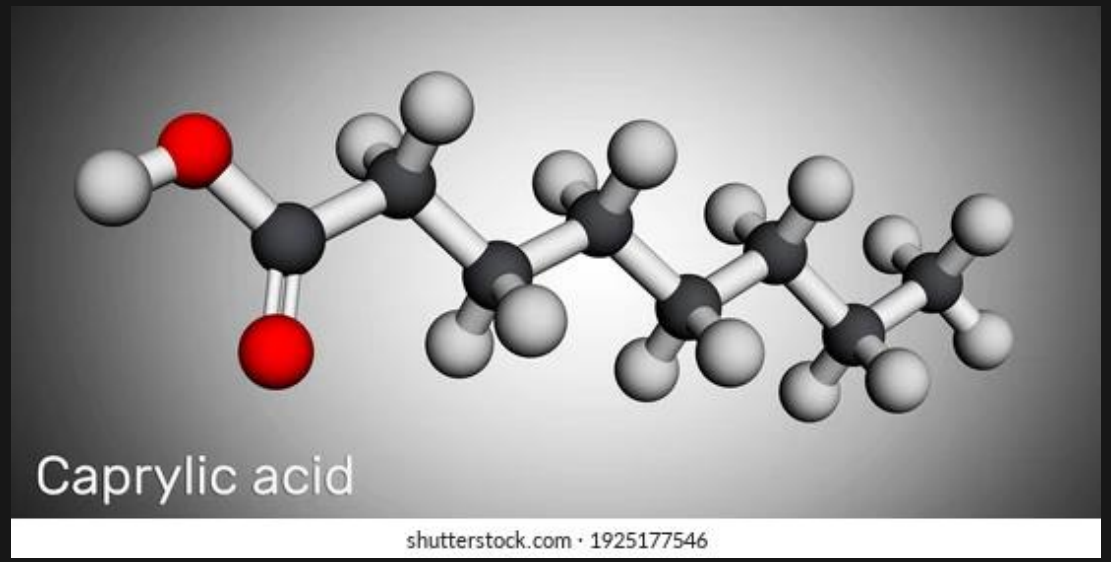

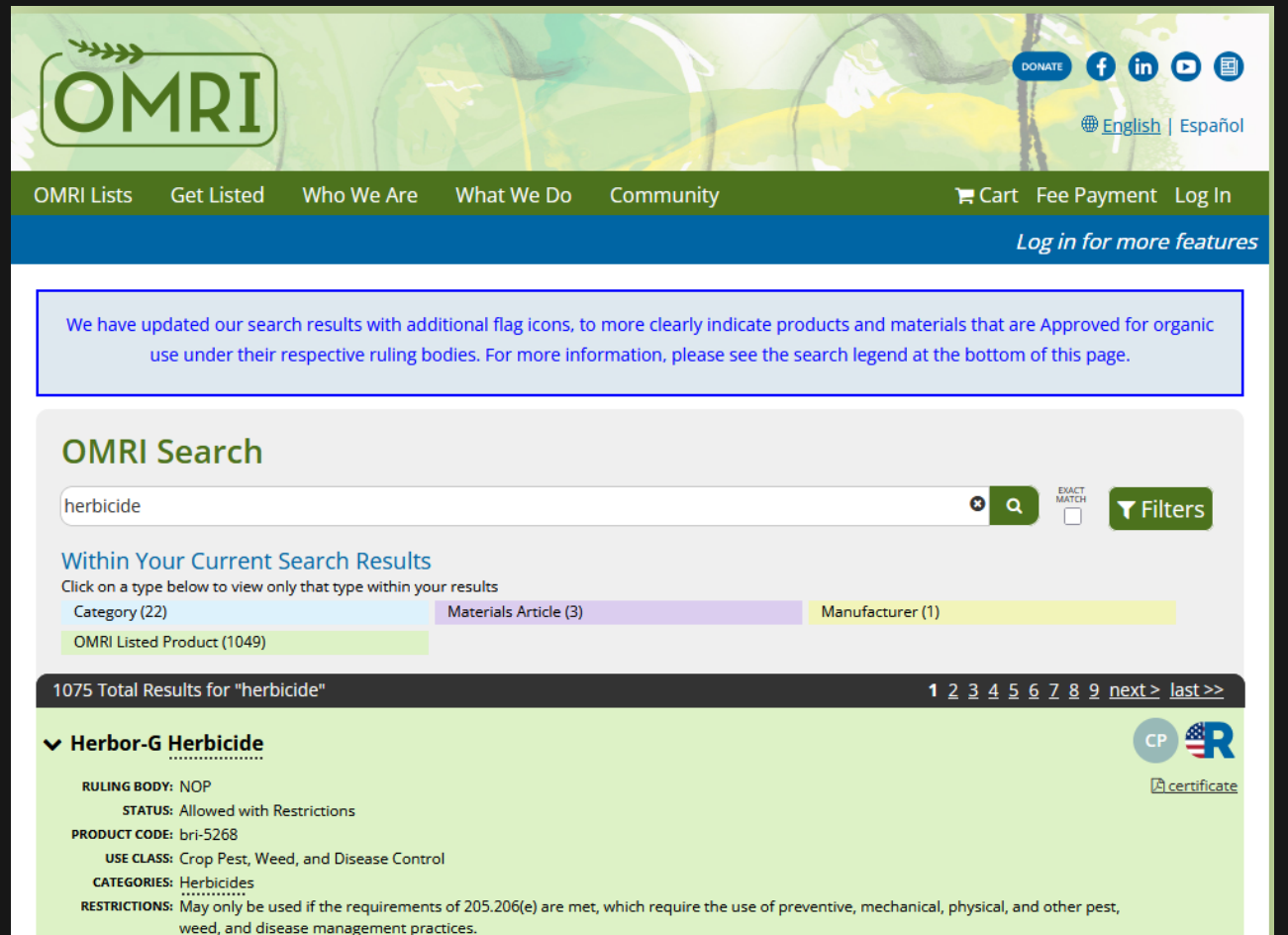

Common Herbicides their Characteristics!

Active Ingredients! Not Trade names…..

- Look at the actives-
- This is going o give you information you need to make decisions.
- Trade names change….
- Actives don't!

Organic Herbicides

- Organic Options!
- “Contact” Products
  - Good at killing small recently emerged weeds
  - Less than a few inches tall
- Acids
  - Acetic Acid
  - Caprylic Acid
  - Capric Acid
  - Citric Acid
  - Ammoniated Soap of Fatty Acids

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  - Citric Acid
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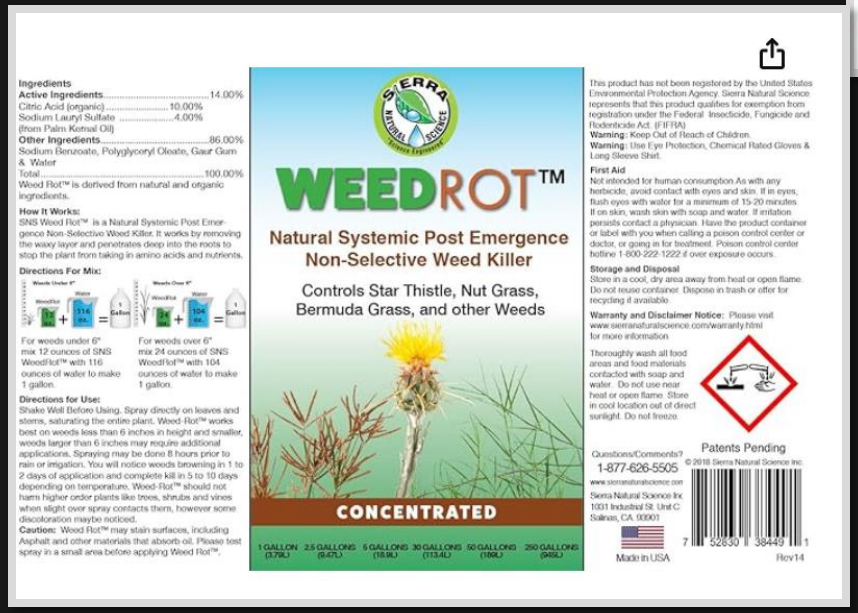
- Oils
  - Clove Oil
  - Cinnamon Oil
  - Citrus oil (d-limonene)
  - Lemon grass oil

Avenger® AG Optima Burndown Herbicide

Organic Herbicides

- “Contact” Products
  - Good at killing small recently emerged weeds
  - Less than a few inches tall

  - Eugenol
  - 2-Phenethyl Propionate
  - Sodium Lauryl Sulfate
  - Ammonium nonanoate
  - Sodium Chloride



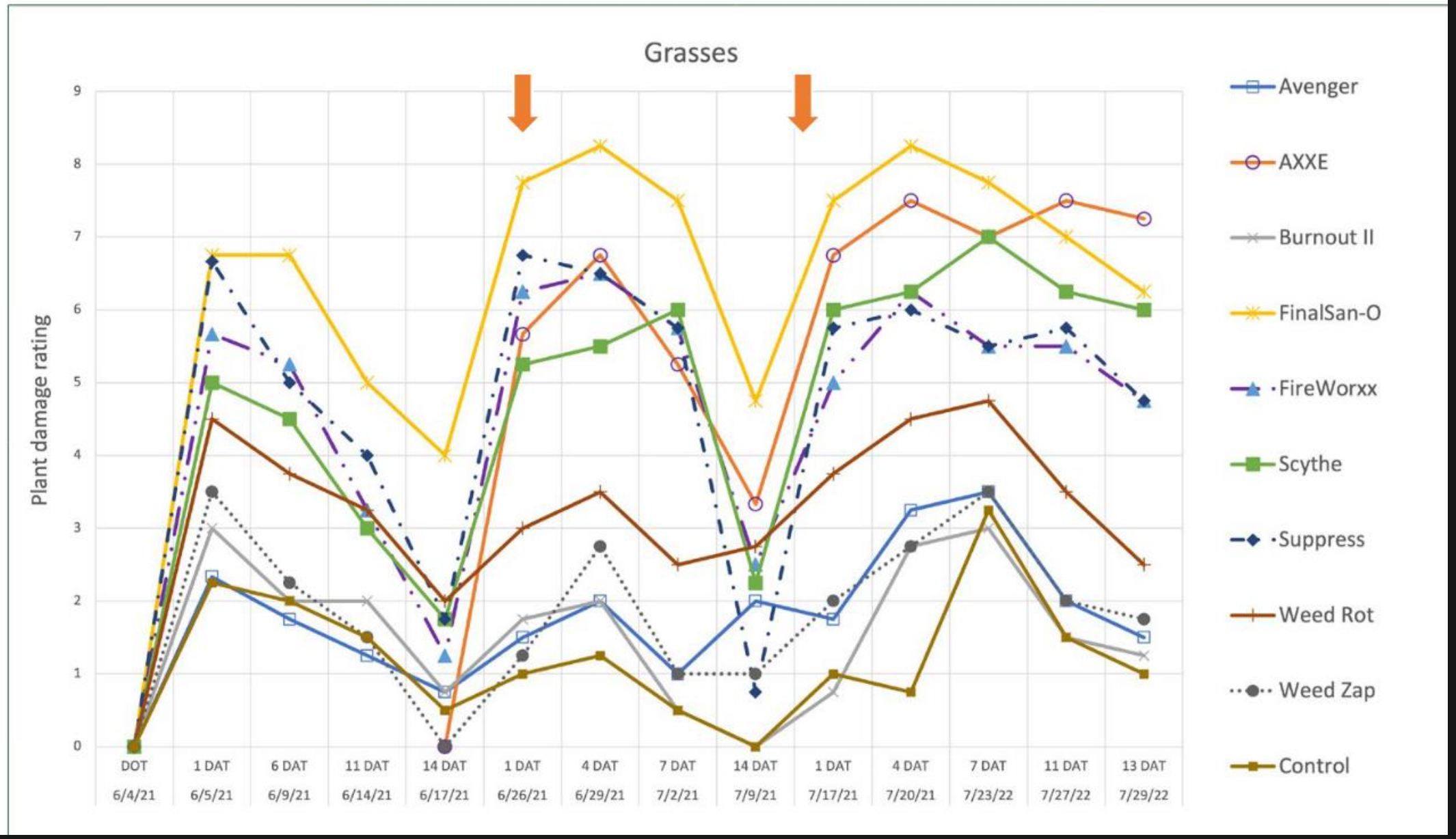
Organic Herbicides

- UC Advisors Karey Windbeil Rojas and Chris McDonald!
- Work done by Maggie Reiter in turf
- Taken from the UC Green Blog Nov 20th 2020
- https://ucanr.edu/blog/green-blog/article/uc-cooperative-extension-studies-organic-herbicides-weed-control-landscapes

- Karey Windbeil Rojas Organic Herbicide Work
  - Green Bulletin Winter 2023

  - https://ipm.ucanr.edu/legacy_assets/pdf/pubs/greenbulletin.winter.2023.pdf

Organic Herbicides, continued



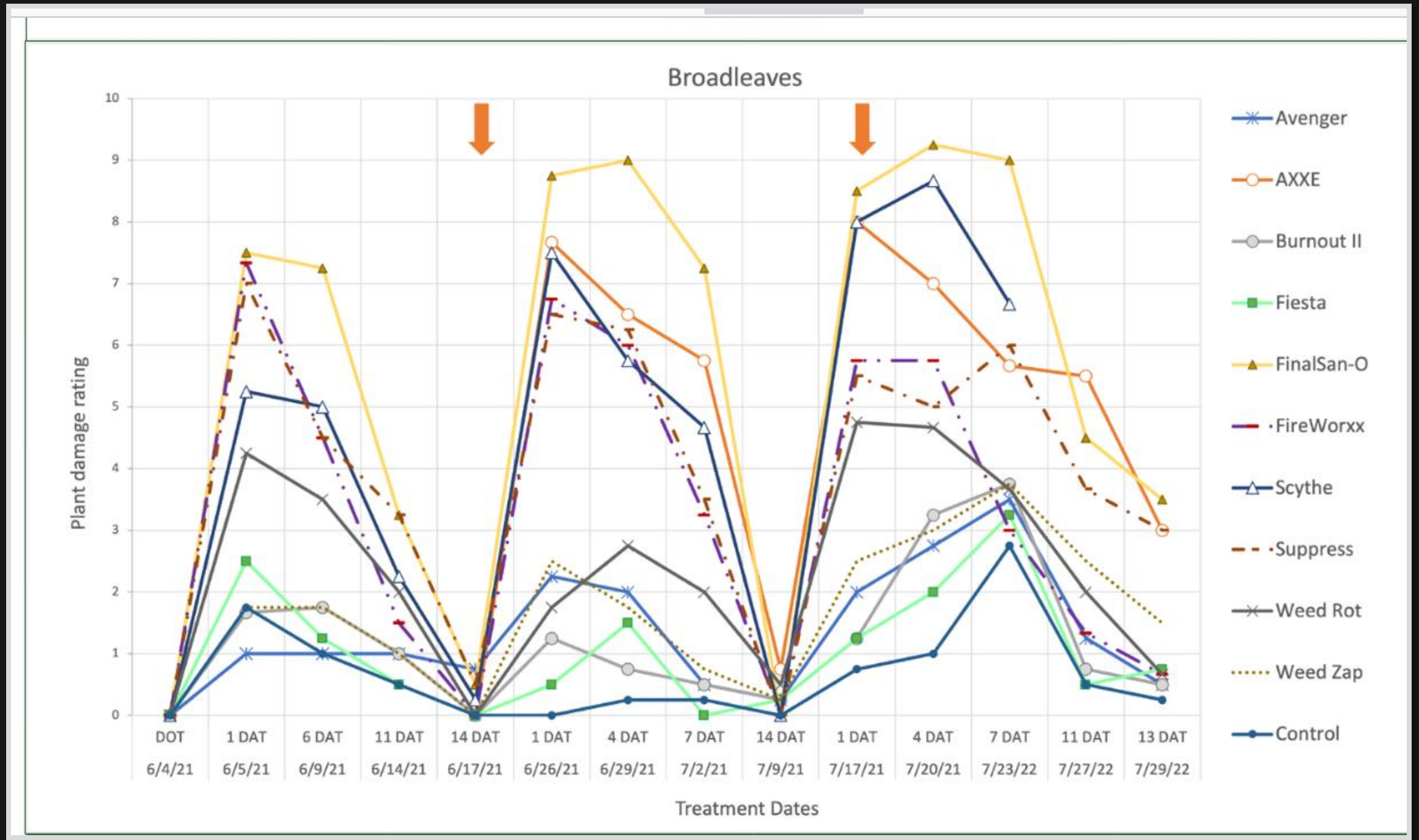

Broadleaves
Plant damage rating
10
9
8
7
6
5
4
3
2
1
0
DOT 6/4/21
1 DAT 6/5/21
6 DAT 6/9/21
11 DAT 6/14/21
14 DAT 6/17/21
1 DAT 6/26/21
4 DAT 6/29/21
7 DAT 7/2/21
14 DAT 7/9/21
1 DAT 7/17/21
4 DAT 7/20/21
7 DAT 7/23/22
11 DAT 7/27/22
13 DAT 7/29/22
Treatment Dates
Avenger
AXXE
Burnout II
Fiesta
FinalSan-O
FireWorxx
Scythe
Suppress
Weed Rot
Weed Zap
Control

Table 1. Herbicide active ingredients, application rates, organic status, and cost for products used in Sacramento experiments.

Product name	Active Ingredients	Signal Word	Organic?	Price/ 2.5 gal	Rate used in trials	Price/ 1000 ft^2
Avenger AG	70% d-limonene	Caution	Yes	$225	6%	$6.20
AXXE	40% ammonium nonanoate	Warning	Yes	$245	10%	$11.25
Burnout II*	24% citric acid, 8% clove oil	Danger	Yes	$100	25%	$11.41
Fiesta	26.52% iron HEDTA	Caution	No	$170	4%	$3.12
Finale	11.33% glufosinate-ammonium	Warning	No	$240	1%	$1.10
FinalSan-O*	22% ammoniated soap of fatty acids	Warning	Yes	$81	17%	$6.29
FireWorxx	44% caprylic acid, 36% capric acid	Caution	No	$122 (1 gal)	6%	$8.40
Nature's Wisdom	20% acetic acid	Danger	Yes	$51 (1 gal)	Full	$58.55
Ranger Pro	41% glyphosate	Caution	No	$115	1%	$0.53
Scythe	57% pelargonic acid, 3% fatty acids	Warning	No	$190	6%	$5.23
Suppress + BioLink	47% caprylic acid, 32% capric acid + 50% citric acid (acidifier)	Warning	Yes	$257	6% + 1%	$5.45
Weed Rot	10% citric acid; 4% sodium lauryl sulfate	Caution	Yes	$156	18.75%	$21.19
Weed Zap	45% clove oil, 45% cinnamon oil	Caution	Yes	$175	6%	$4.81

Cost was calculated in July 2022. Prices vary by distributor and market fluctuation.
*Product has changed or no longer sold. For these, price is from 2019 when product was obtained for this research.

Figure 1. Burndown activity can be seen quickly after application of many contact organic herbicides.
DAT = days after treatment

Coverage Matters!

TJ Mason- Colorado State

level of weed injury ≥50% (Patton et al., 2019). Similarly, the weed injury increased with increasing percent concentrations of caprylic/capric acid (Figure 7).

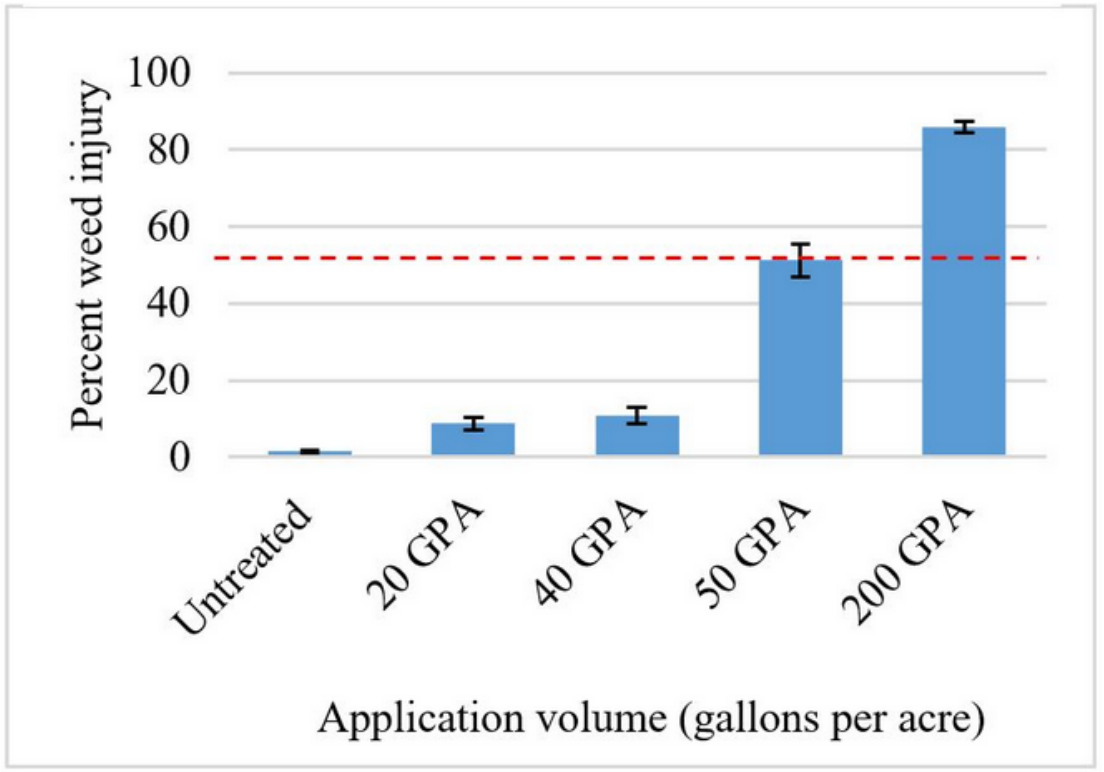


Figure 6. Caprylic/capric acid herbicide lead to more weed injury with increasing concentrations of product applied; red line indicates the minimum acceptable level of weed injury (>50%).

https://extension.colostate.edu/topic-areas/agriculture/capric-acid-a-promising-next-generation-herbicide-for-organic-specialty-crop-production-0-314/

No Systemic Organic Options!

- Limited Organic options with Pre Control
- Corn Gluten Meal?
  - Greenhouse Trials some activity!
    - 50-90% control of germinating seeds
  - Turfgrass crabgrass suppression but not control….
  - Limited effectiveness in various felid trials
  - Suppression!
  - Contains Nitrogen- may favor certain weeds
- Also can impact seeded species.
- Good review by Cornell!

https://ecommons.cornell.edu/server/api/core/bitstreams/d319093d-af07-43d0-941b-ec7ea433dc71/content

Organic Herbicide's Overview

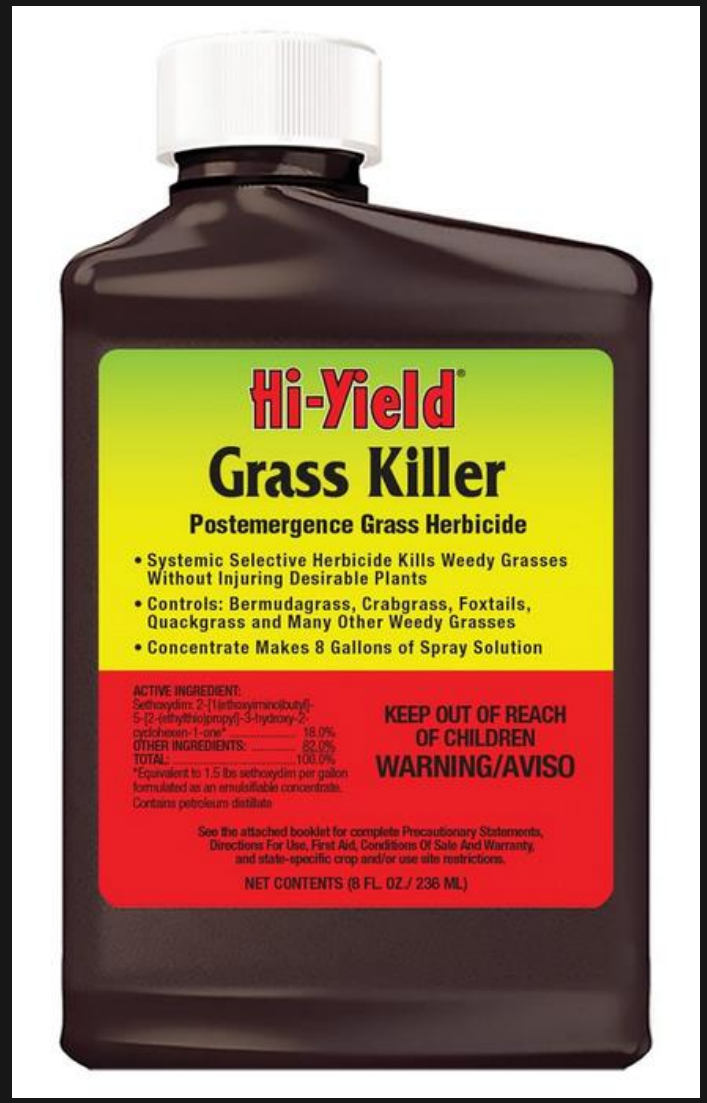
- Pro's/ When to Use
  - Recent emerged small weeds
  - Small areas
- Con's
  - Expensive
  - Not systemic
  - Repeat applications necessary
  - Limited to no soil activity
  - Will no kill perennial weeds/ only gets top growth
- Organic/Natural does not mean "safe"

Conventional “Contact” Herbicides “Fast Acting”

- Photo System 1-inhibitor
  - Diquat-(Broadleaf and grasses)
- Acid
  - Pelargonic Acid
- Often in Mix with Other Products

Grass Killers!

- ACCace Herbicides
  - Fop's and Dim's
- Over The Top, Grass killer, Grass B gone, Grass Beater
- Garden Beds, Some Vegetables etc.
- NOT FOR LAWNS!!!
  - Inhibit formation of long chain fatty acid's
  - Grass killers!
  - Post activity
  - Examples
    - Clethodim
    - Sethoxydim
    - Fluazifop



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    - Fluazifop

Plant Hormone Mimics (Synthetic Auxins)

- Kill **Broadleaf Weeds**
- Generally “safe” on Grasses
- Systemic
- Post and Pre?
  - 2,4-D
  - Dicamba
  - MCPA
  - Quinclorac
  - Triclopyr
  - Clopyralid
- Lawns Vs. Other Broadleaf's?

Triclopyr

- Broadleaf killer
- Brush Killer
- Stump killer
- Vine Killer
  - Paint on Cut Stumps
  - Or foliar applications.

Hover Image to Zoom

Clopyralid

- More “ranchette” use than homeowner use
- Yellow Star thistle Killer
- Or “thistledown”
- Other Broadleaf's
- Pre and Post emergent activity

Lawn Mixes/Products

- Auxins
- Systemic
  - 2,4-D
  - Dicamba
  - MCPA
  - Quinclorac
    - Crab Grass!
- PPO Inhibitors
- Contact
  - Sulfentrazone

Lawn- “Weed N Feed’s”

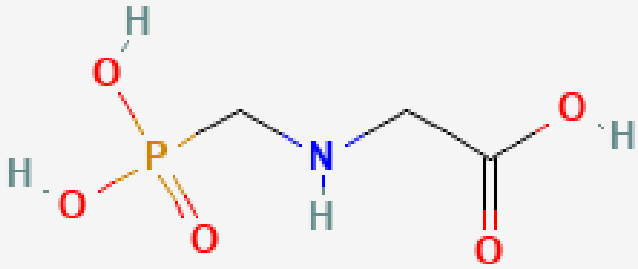
- Not my favorite…..
- Have their place.

- Questions
  - Do you need fertilizer?
  - Do you have weeds?

- 2,4-D
- Quincorlac
- Dicamba
- MCPA

Glyphosate

- Trade Name
  - Roundup, Mad Dog, Killzall
- MOA-ESPS Synthase
- Broad spectrum Systemic
    - Grasses
    - Broadleaf's
    - Trees
  - NO RESIDUAL
    - No soil activity
    - Bound to soil
  - Excellent to plant after spraying
  - Short term bare ground
  - Tank mix
  - Aquatic formulations available



Glyphosate

- In the News! Toxicity/Cancer….
- https://ipm.ucanr.edu/legacy_assets/PDF/PUBS/greenbulletin.2019.fall.pdf
- EPA, DPR, WHO etc.
- Bayer Lawsuits

- **Roundup NO LONGER≠ Glyphosate for homeowners!**

Information for pest management professionals and pesticide applicators

UC IPM Green Bulletin

University of California
Agriculture and Natural Resources

Vol. 9 • No. 3 • Fall 2019

Addressing the Science Surrounding Glyphosate

UC ANR's charge is research and extension and we provide guidance about how to manage weeds using registered pesticides and by non-chemical methods. UC ANR includes information in its publications on how to effectively and safely use glyphosate where it is legal to do so as well as provide options for alternative chemical and non-chemical approaches for managing weeds.

UC ANR recognizes that the use of any pesticide carries risks, including in some cases the possibility of acute (immediate), chronic (long term) or carcinogenic effects, to those who may be exposed to them. This is true of any pesticide, which includes herbicides such as glyphosate.

UC ANR has not specifically addressed carcinogenicity or other

States have not significantly changed the legal uses of glyphosate herbicides.

What is risk?

The specific risks of a pesticide are a function of both hazard (toxicity) and exposure; the risks from more hazardous materials can often be reduced by minimizing exposure (e.g. strictly following the directions on the label, using proper personal protective equipment, and using appropriate application methods). Conversely, high exposure levels (e.g. large concentrations, frequent exposure, long-term exposure) to a relatively lower hazard material has the potential to increase health risks.

What is glyphosate?

Glyphosate is the active ingredient

JACK KELLY CLARK, UCIPM

Application of an herbicide.

specific uses (e.g. cut stump treatments, no-surfactant formulations for some aquatic uses). Most glyphosate herbicides used in agriculture and commercial applications are sold as

Triclopyr-Broadleaf killer
Fluazifop-Grass Killer
Diquat- Contact/quick browning

MCPA-Broadleaf killer
Dicamba-Broadleaf Killer
Quincorlac-Crabgrass killer
Sulfentrazone- Pre and Post- Broadleaf and Nutsedge

Triclopyr-Broadleaf killer
Fluazifop-Grass Killer
Diquat- Contact/quick browning
Imazapic(0.3 %)- pre emergent control grasses and broadleafs

Triclopyr-Broadleaf killer
Fluazifop-Grass Killer
Diquat- Contact/quick browning
Imazapic(1.6 %)- pre emergent control grasses and broadleafs

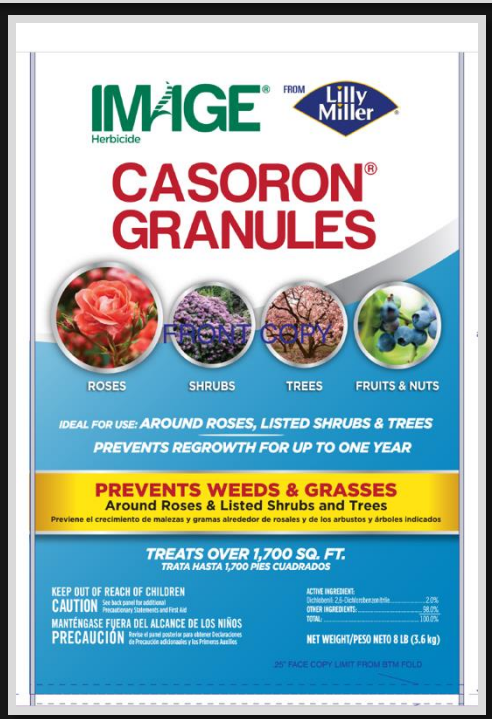
Pendimethalin- Seeds

Bare Ground/Total Vegetation Control

- Gravel, Dirt Driveways etc.
- Pre + Post
- Roundup 365
  - Posts + Imazapic
- Ortho year Long Ground Clear
  - Imazapyr + Pelergonic Acid
- RM43
  - Glyphosate + Imazapyr
- Roundup Quick Pro
  - Glyphosate + Indaziflam
- Imazapyr and Imazapic- Need to be Careful around Tree roots!!

Pre Emergent Control!

- Prevents seeds from Germinating!
- Around ornamentals
- In lawns?
- Granulars and sprays
- Microtubular inhibitors
  - Trifluralin
  - Oryzalin
  - Pendimethalin
- Cellulose Biosynthesis inhibitors
  - Dichlobenil
  - Isoxaben
- Need to be incorporated!



Bare Ground and Pre Emergent Herbicides!

- Carry over
- Soil activity
- Can prevent seeds from germinating or transplants from growing!
- Think about future plans before applying

Proper growth stage cannot be overstated!

- Small weeds easier to kill
- Actively growing weeds easier to kill
- Don’t go after your “trophy” Weeds (Earl Creech Utah State Extension)
- On the Label!

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Biology of the plant!

- Annuals and biennials
  - Pre-emergent
  - Contact (when small!)
  - Systemic
- Multiple flushes….
- Perennial's
  - Root systems
  - Systemic herbicides needed
- **Read the Label**
  - Species targeted
  - Use Sites!

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Common application types

- Granular
  - Amount/area

Hover Image to Zoom

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  - Often Spray to Wet
  - Buying lots of water!
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  - Buying lots of water!
  - Good for small areas
- Hose End Sprayers
  - Often for Lawns
  - Pre Mix and Mix your own

Common application types

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  - Good for small areas
- Hose End Sprayers
  - Often for Lawns
  - Pre Mix and Mix your own
- Concentrates
  - Mix your own
  - Pump, Hand, Backpack!

Common application types

- Granular
  - Amount/area
- Ready to Use Spray
  - Often Spray to Wet
  - Buying lots of water!
  - Good for small areas
- Hose End Sprayers
  - Often for Lawns
  - Pre Mix and Mix your own
- Concentrates
  - Mix your own
  - Pump, Hand, Backpack!
- Weed Wicks/Sponges

Read the Label!

- How much to mix?
  - Par per gallon
    - Spray to wet
    - Don't spray to runoff
  - Amount per area
    - Oz/1000 Square Ft.
    - Liquid or Granular over area
  - Calibration is important!
- Under Applying
  - Failed application
- Over Application
  - Illegal!!!
  - Off Target Impacts
  - Water quality
  - Negative environmental harm

Read the Label!

- How much to mix?
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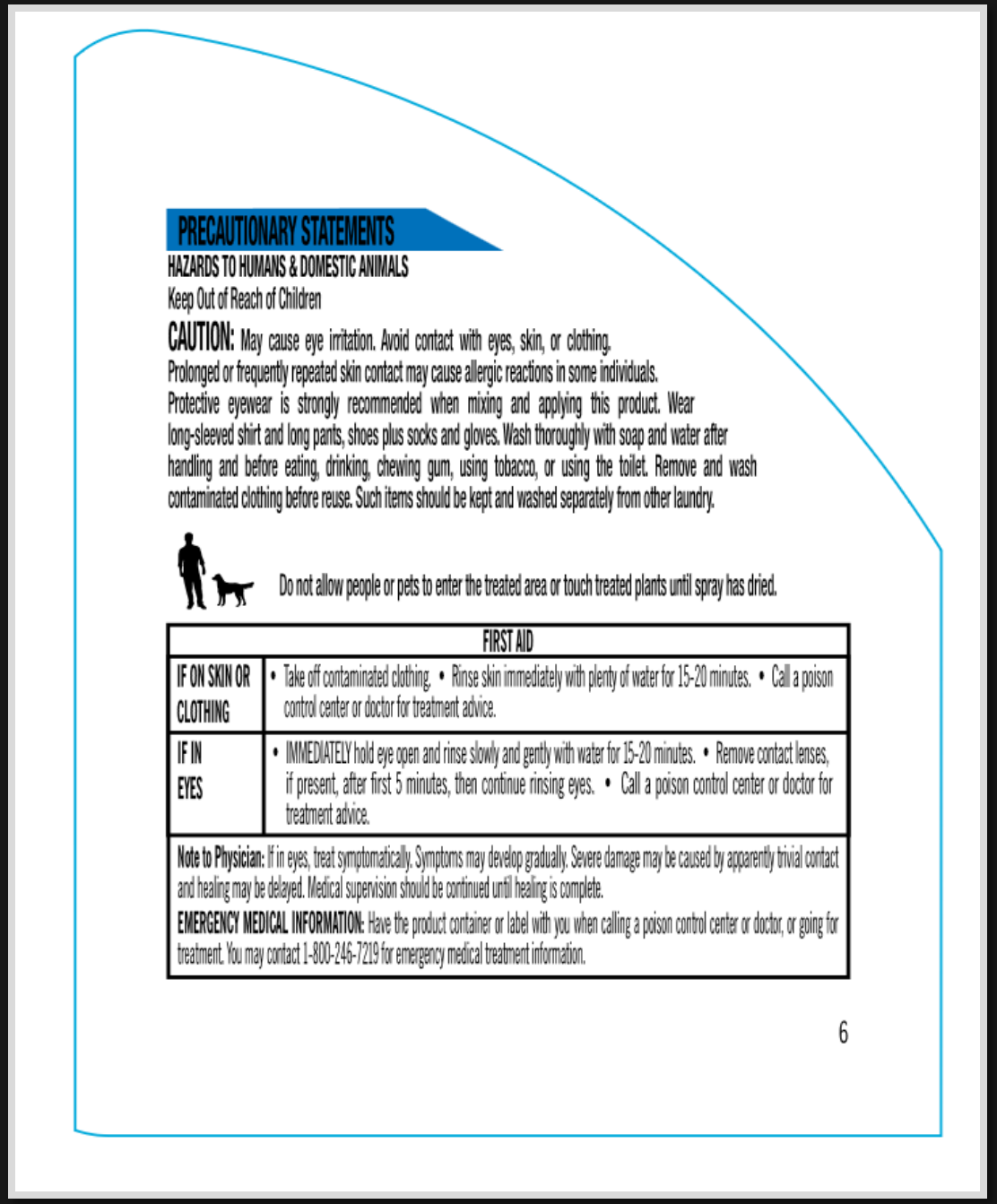

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS & DOMESTIC ANIMALS

Keep Out of Reach of Children

CAUTION: May cause eye irritation. Avoid contact with eyes, skin, or clothing. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Protective eyewear is strongly recommended when mixing and applying this product. Wear long-sleeved shirt and long pants, shoes plus socks and gloves. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse. Such items should be kept and washed separately from other laundry.

Do not allow people or pets to enter the treated area or touch treated plants until spray has dried.

FIRST AID	
IF ON SKIN OR CLOTHING	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
IF IN EYES	• IMMEDIATELY hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after first 5 minutes, then continue rinsing eyes. • Call a poison control center or doctor for treatment advice.

Note to Physician: If in eyes, treat symptomatically. Symptoms may develop gradually. Severe damage may be caused by apparently trivial contact and healing may be delayed. Medical supervision should be continued until healing is complete.

EMERGENCY MEDICAL INFORMATION: Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may contact 1-800-246-7219 for emergency medical treatment information.

6

Read the Label!

- How much to mix?
  - Par per gallon
    - Spray to wet
    - Don't spray to runoff
  - Amount per area
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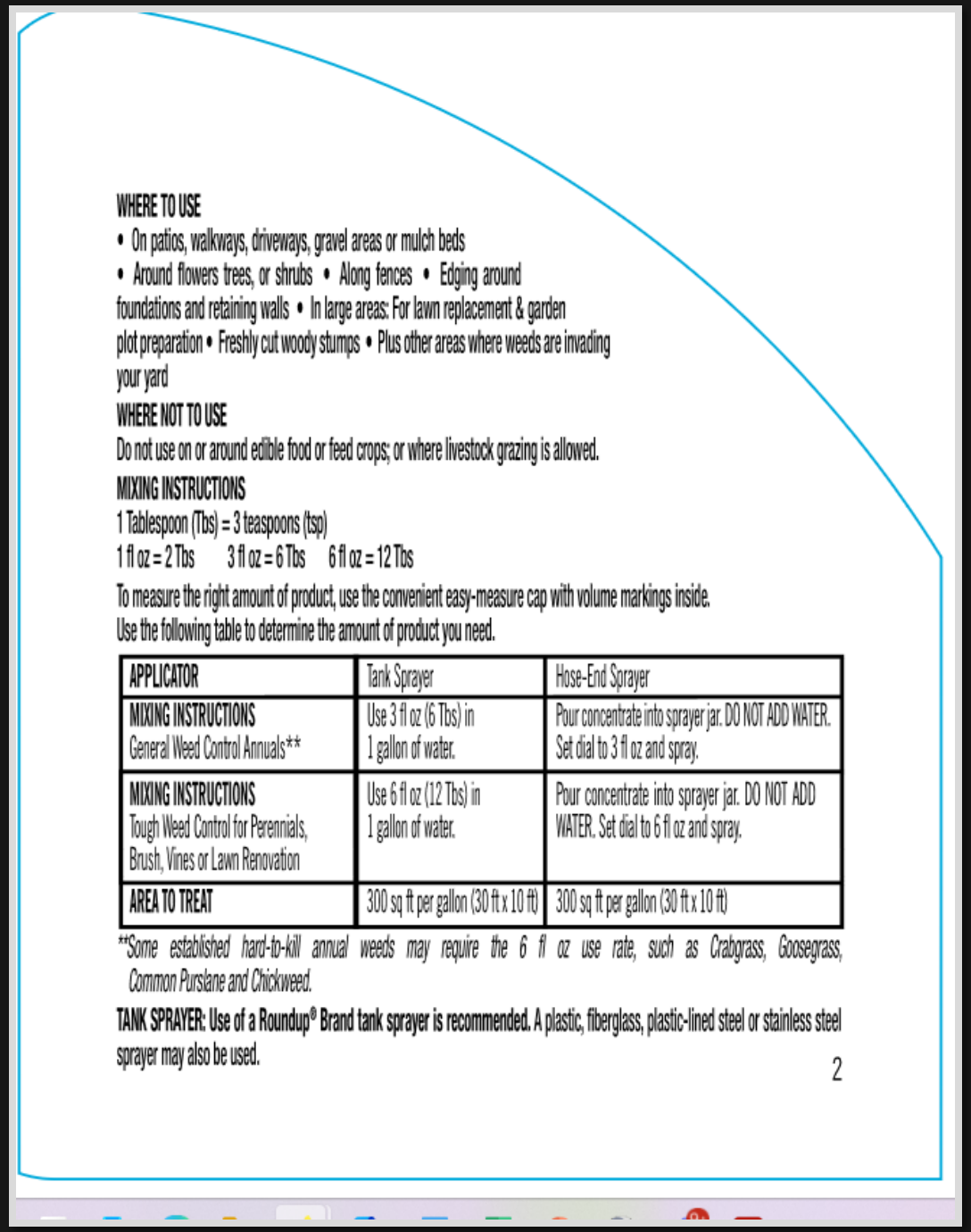


WHERE TO USE

• On patios, walkways, driveways, gravel areas or mulch beds • Around flowers trees, or shrubs • Along fences • Edging around foundations and retaining walls • In large areas: For lawn replacement & garden plot preparation • Freshly cut woody stumps • Plus other areas where weeds are invading your yard

WHERE NOT TO USE

Do not use on or around edible food or feed crops; or where livestock grazing is allowed.

MIXING INSTRUCTIONS

1 Tablespoon (Tbs) = 3 teaspoons (tsp)
1 fl oz = 2 Tbs 3 fl oz = 6 Tbs 6 fl oz = 12 Tbs

To measure the right amount of product, use the convenient easy-measure cap with volume markings inside. Use the following table to determine the amount of product you need.

APPLICATOR	Tank Sprayer	Hose-End Sprayer
MIXING INSTRUCTIONS General Weed Control Annuals**	Use 3 fl oz (6 Tbs) in 1 gallon of water.	Pour concentrate into sprayer jar. DO NOT ADD WATER. Set dial to 3 fl oz and spray.
MIXING INSTRUCTIONS Tough Weed Control for Perennials, Brush, Vines or Lawn Renovation	Use 6 fl oz (12 Tbs) in 1 gallon of water.	Pour concentrate into sprayer jar. DO NOT ADD WATER. Set dial to 6 fl oz and spray.
AREA TO TREAT	300 sq ft per gallon (30 ft x 10 ft)	300 sq ft per gallon (30 ft x 10 ft)

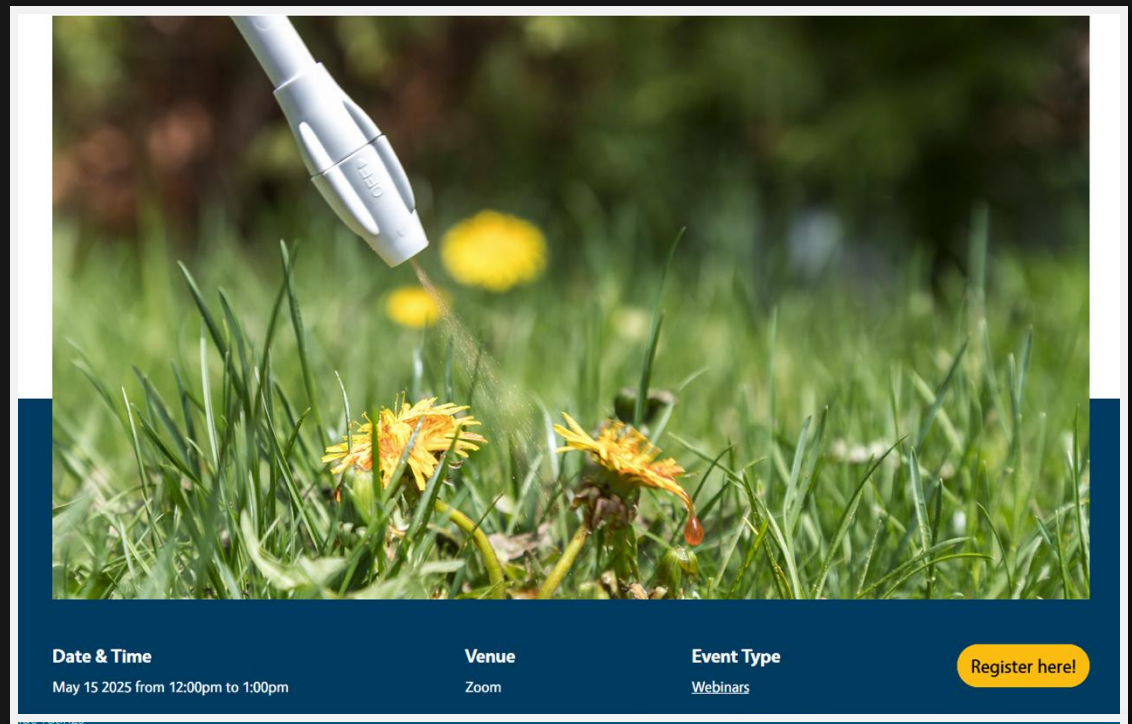
***Some established hard-to-kill annual weeds may require the 6 fl oz use rate, such as Crabgrass, Goosegrass, Common Purslane and Chickweed.*

TANK SPRAYER: Use of a Roundup® Brand tank sprayer is recommended. A plastic, fiberglass, plastic-lined steel or stainless steel sprayer may also be used.

2

Pollinators!

- Try not to spray flowering plants
  - (Get them when small)
- Apply very late in the day when pollinators are not active
- Check UC Bee Precaution Pesticide Ratings
  - https://ipm.ucanr.edu/bee-precaution-pesticide-ratings/



Date & Time	Venue	Event Type	
May 15 2025 from 12:00pm to 1:00pm	Zoom	Webinars	Register here!

Bee Precaution Pesticide Ratings

Guidance on how to reduce bee poisoning, based on reported pesticide effects on adults and brood of honey bees and other bee species. Ratings are for the pesticide active ingredient, the common name.*

I Do not apply or allow to drift to plants that are flowering including weeds. Do not allow pesticide to contaminate water accessible to bees including puddles.

II Do not apply or allow to drift to plants that are flowering including weeds, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations. Do not allow pesticide to contaminate water accessible to bees including puddles.

III No bee precaution, except when required by the pesticide label or regulations.

Note: These are not the pollinator precautionary statements on the pesticide labels. Some of the listed pesticides are not registered, or approved, for use. Make sure the pesticide use is legal and appropriate before making any application. Always read the label and know and follow the applicable laws and regulations before making any pesticide application. Follow best management practices to protect bees from pesticides.

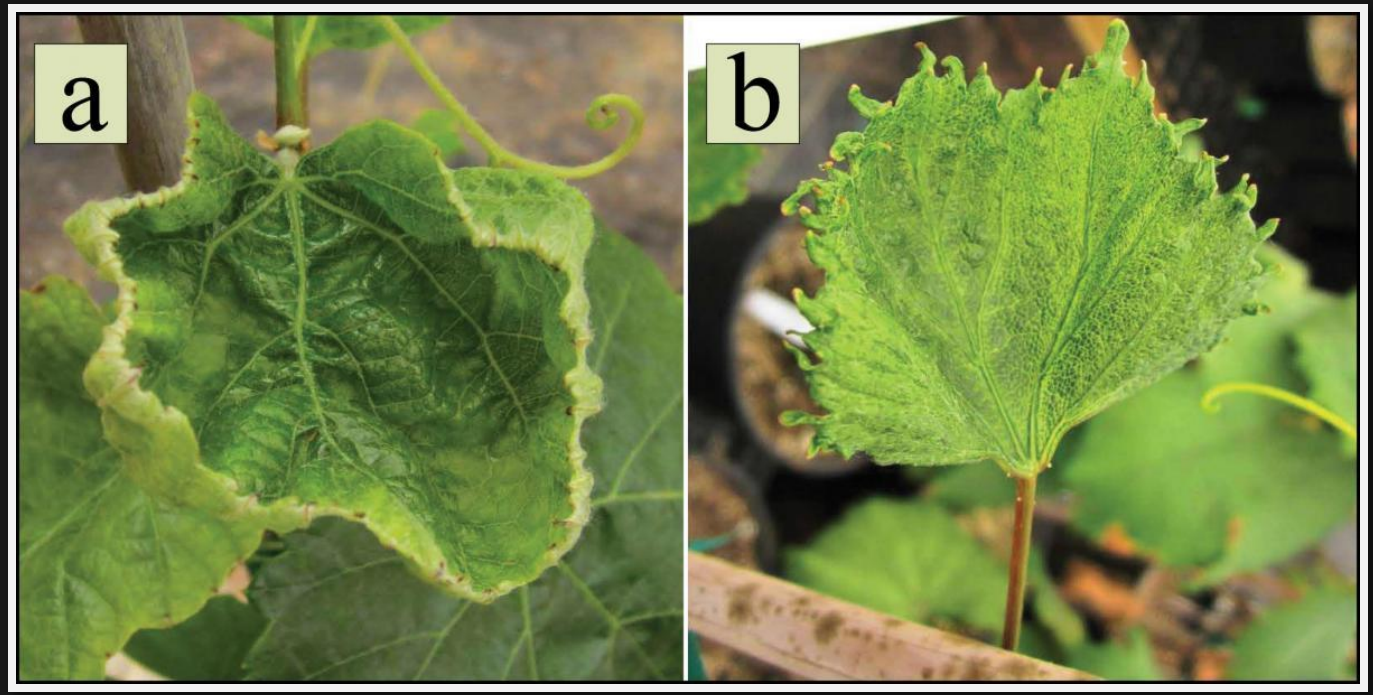
Frequently asked questions (FAQs) about this tool.

◉ Common name ○ Trade name → All types → GLYPHOSATE Add to list

Common name (Example trade name)	Type	Mode of action	Rating	Other effects on bees	Toxic to honey bee brood	Toxic to other bee species
2,4-D (Clean-crop, Orchard Master)	Herbicide	O·4	II	—	✔	—
GLYPHOSATE (Roundup, Touchdown, Weathermax)	Herbicide	G·9	II	—	✔	—
PENDIMETHALIN (Pendulum, Pre-M, Prowl H2O)	Herbicide	K1·3	III	Indirect	—	—

Drift/Volatility

- Drift= Physical movement of pesticide droplets
  - Lower pressure
  - Don’t spray in the wind!
  - Movement onto non target plants
  - Inversions
- Volatility
  - Vaporization of pesticide
  - Movement onto non target plants
  - Common with 2,4-D, Dicamba, Triclopyr
  - Tomato's and Grapes Sensitive!
- Detailed Information
  - https://ucanr.edu/site/herbicide-symptoms/herbicide-damage



Herbicide Resistance

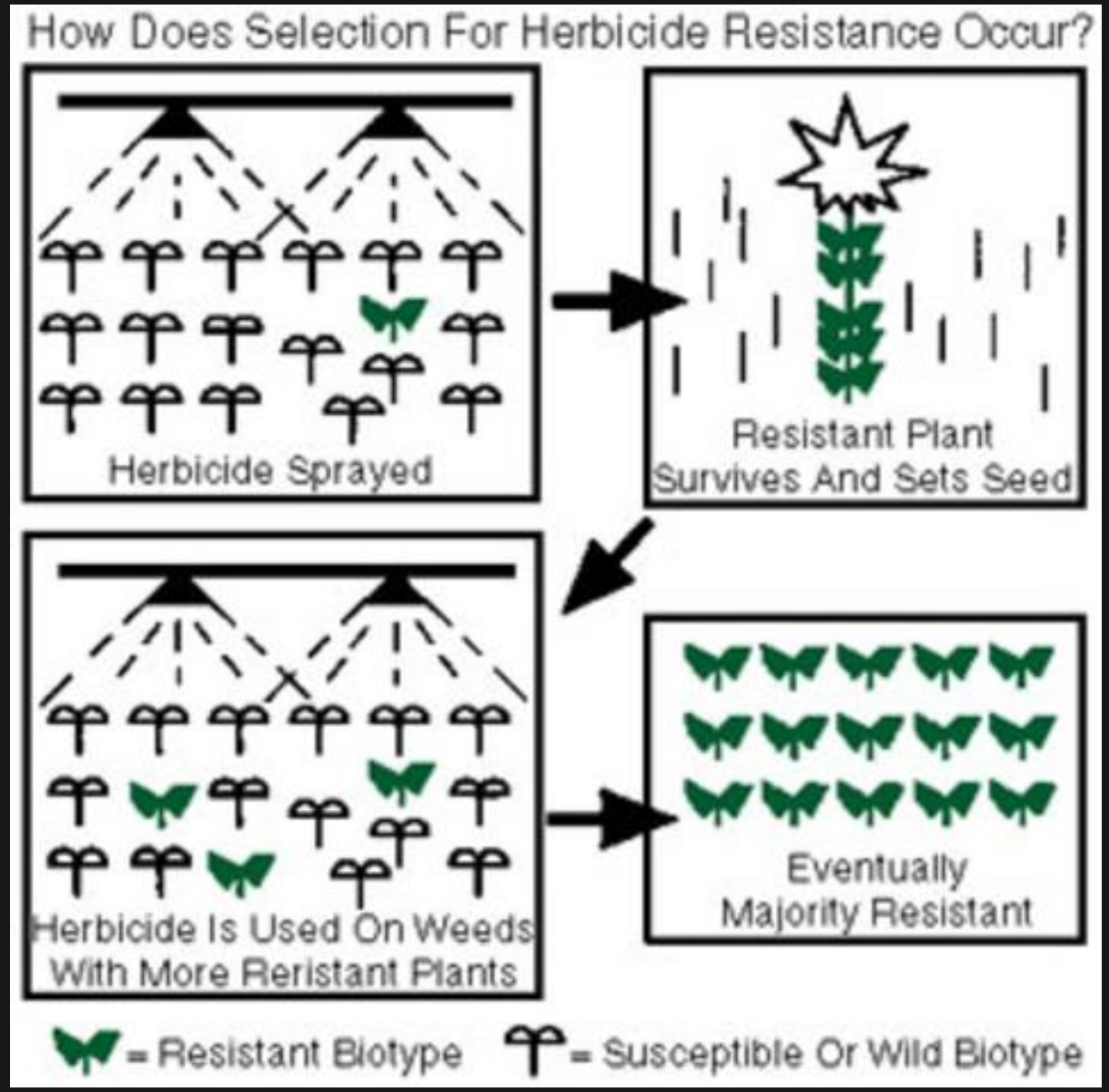
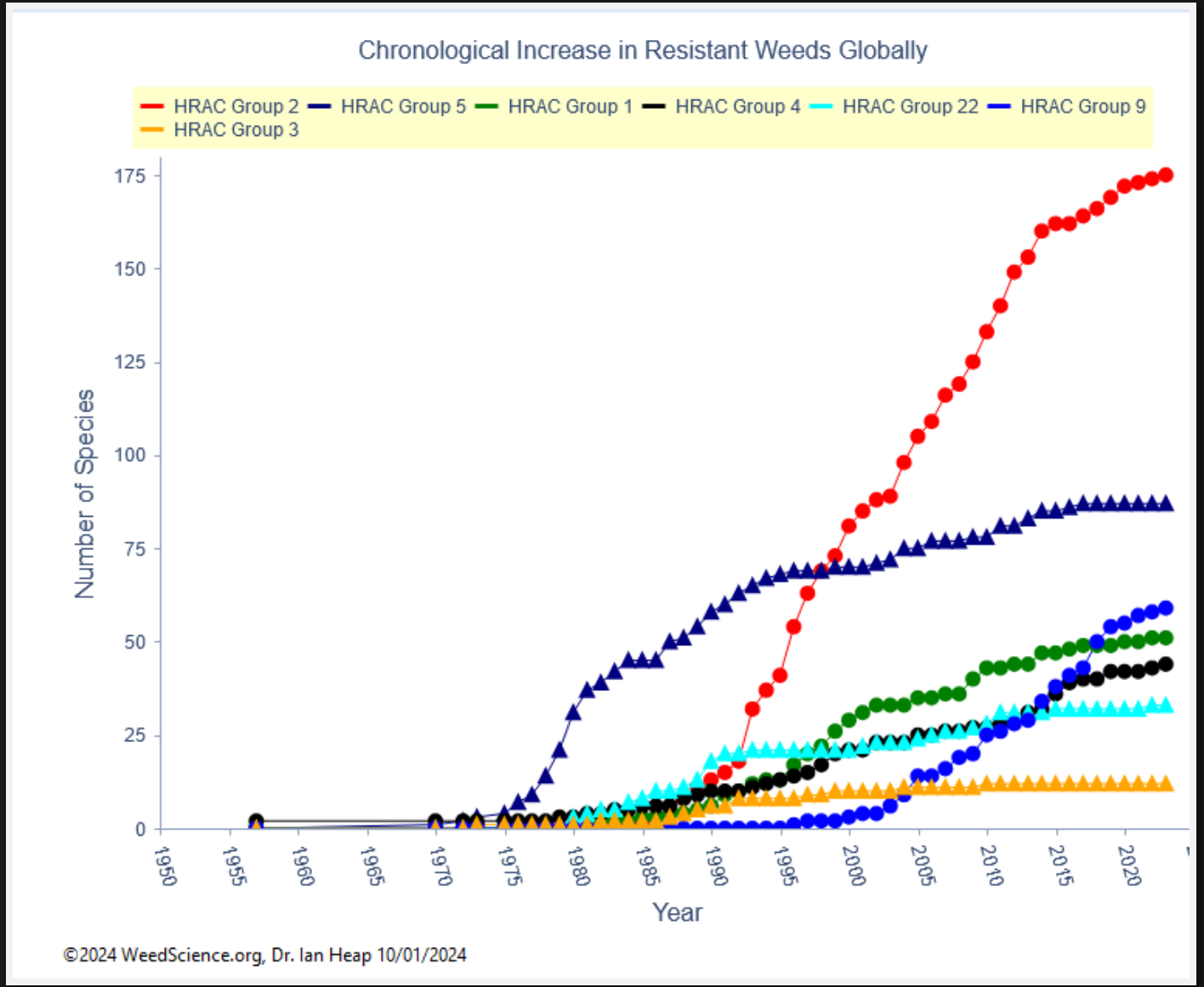


Image courtesy of Minnesota Extension

Resistance world wide!

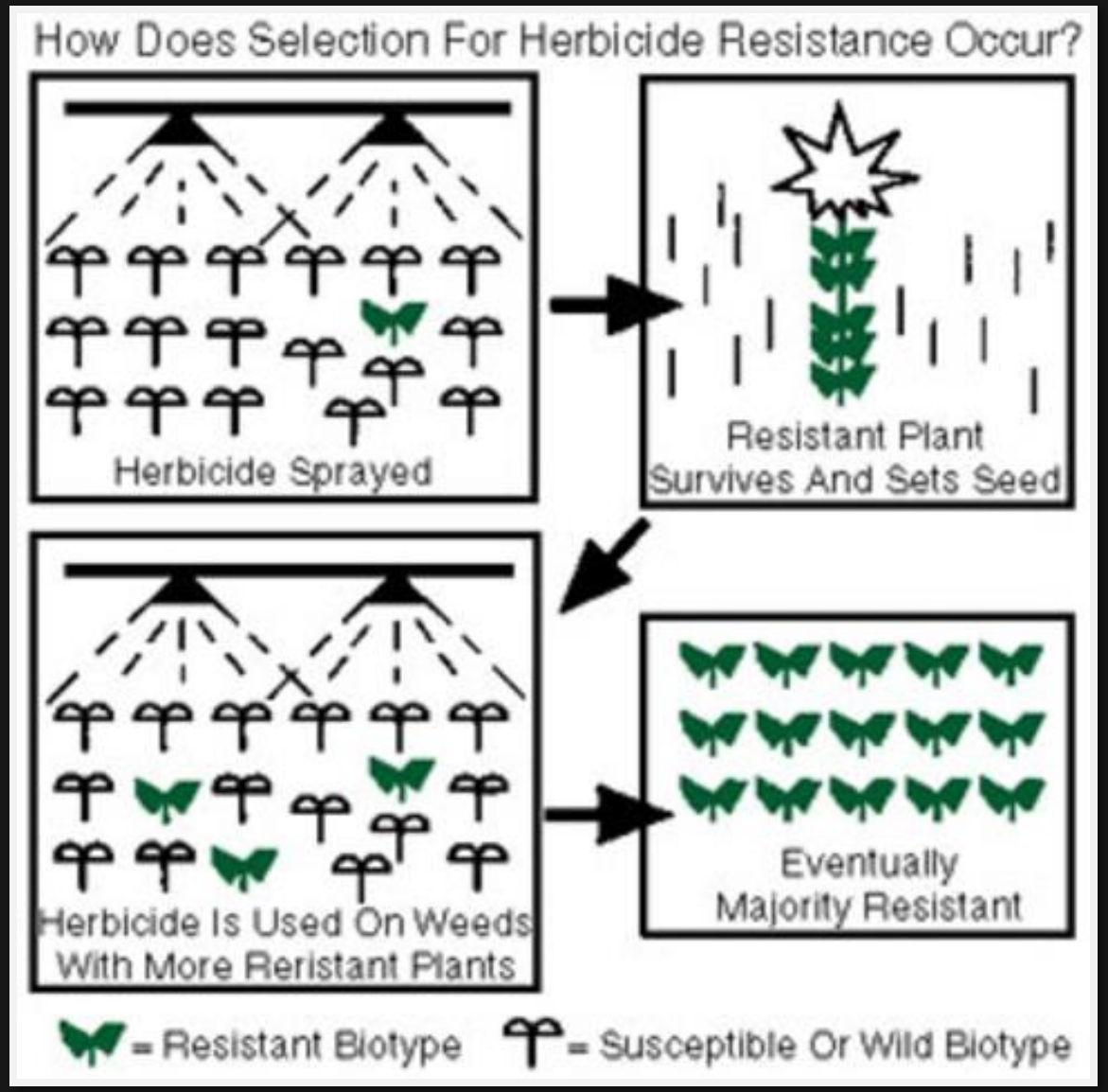
- 515 Cases Since 2020



Herbicide site of action (WSSA Group)	Active ingredient	Weed species
Acetolactate synthase (ALS) inhibitors (WSSA 2)	bensufuron-methyl bensulfuron-methyl bensulfuron-methyl sulfometuron-methyl bensulfuron-methyl bensulfuron-methyl sulfometuron-methyl	*Ammannia auriculata* (eared redstem) *Ammannia coccinea* (redstem) *Cyperus difformis* (smallflower umbrella sedge) *Lolium perenne* (perennial ryegrass) *Sagittaria montevidensis* (California arrowhead) *Schoenplectus mucronatus* (ricefield bulrush) *Salsola tragus* (Russian thistle)
5-enol-pyruvyl-shikimate-3-phosphate synthase (EPSPS) inhibitor (WSSA 9)	glyphosate glyphosate glyphosate glyphosate glyphosate glyphosate glyphosate	*Amaranthus palmeri* (Palmer amaranth) *Conyza bonariensis* (hairy fleabane) *Conyza canadensis* (horseweed) *Echinochloa colona* (junglerice) *Lolium perenne* ssp. *multiflorum* (Italian ryegrass) *Lolium rigidum* (rigid ryegrass) *Poa annua* (Annual bluegrass)
Acetyl-CoA carboxylase (ACCase) inhibitors (WSSA 1)	fenoxaprop-p-ethyl clethodim fenoxaprop-p-ethyl fluazifop-p-butyl sethoxydim	*Echinochloa phyllopogon* (late watergrass) *Phalaris minor* (littleseed canary grass)
Photosystem II (PS II) inhibitors (WSSA 7)	propanil propanil atrazine	*Cyperus difformis* (smallflower umbrella sedge) *Schoenplectus mucronatus* (ricefield bulrush) *Senecio vulgaris* (common groundsel)
Lipid synthesis inhibitors (WSSA 8)	difenzoquat thiobencarb thiobencarb	*Avena fatua* (wild oats) *Echinochloa phyllopogon* (late watergrass) *Echinochloa oryzoides* (early watergrass)
Synthetic auxins (WSSA 4)	quinclorac	*Digitaria ischaemum* (smooth crabgrass)
Glutamine synthase inhibitors (WSSA 10)	glufosinate	*Lolium perenne* ssp. *multiflorum* (Italian ryegrass)

Minimize resistance!

- Integrate IPM
  - Cultural
  - Physical
  - Biological
- Combine multiple effective modes of action
  - Rotation?
- Not common to develop in gardens, but in crops and rights of ways common.
- Can move from Ag/Roadways.
- If a weed doesn't die and you think it should/ Pull it!



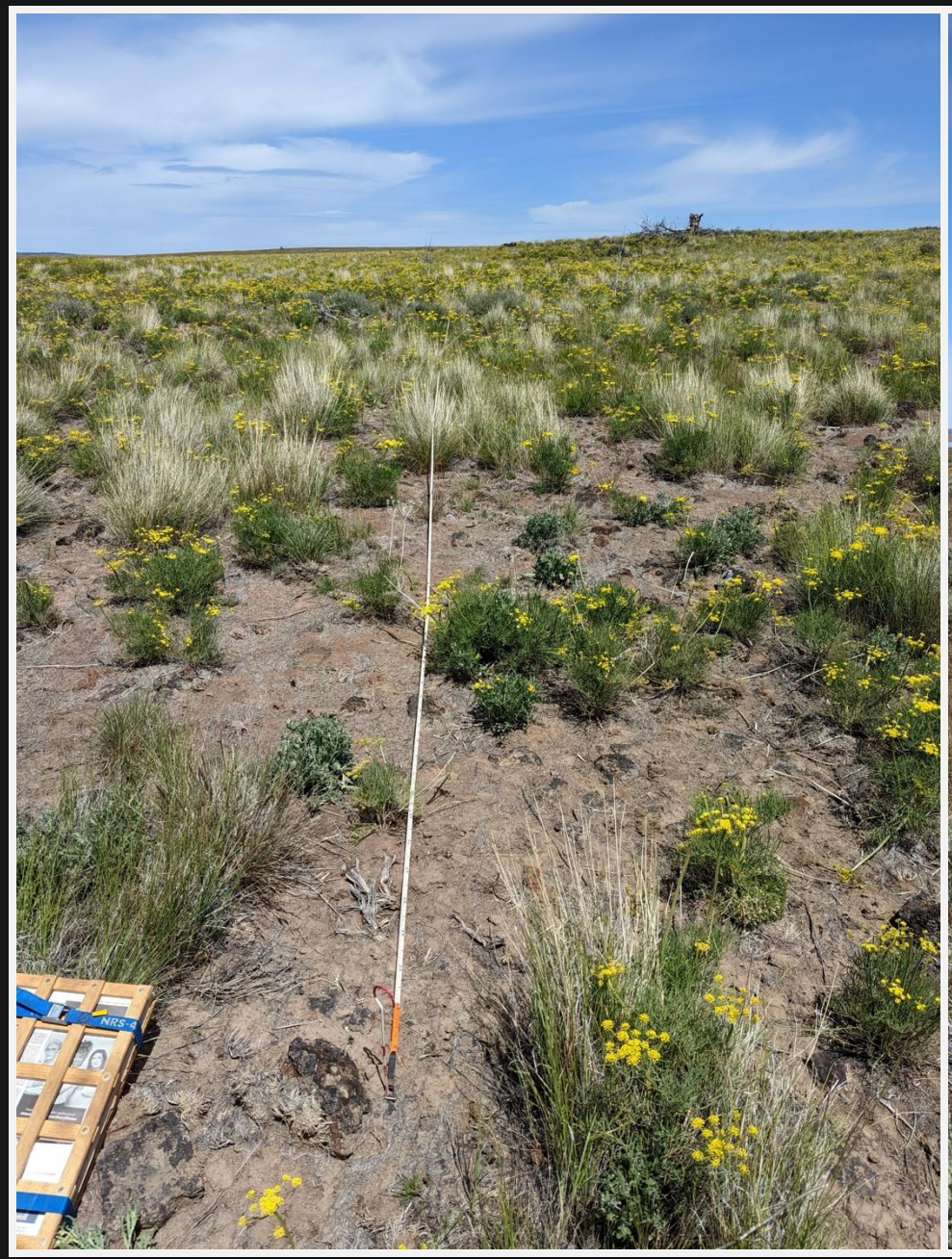
More Information!

- UC IPM
- UC Extension
- Uc Master Gardners
- Other State's University Extension Services
  - Nevada, Oregon, Idaho, Cornell, Purdue Etc.
- USDA NRCS
- Vetted information….
  - Garden Blogs
  - Reddit
  - Online Forums
  - Take with a grain of salt….. (Or a whole Shaker!)

Powerful Tools Use Responsibly!

Herbicides

- Powerful tools
  - Heavily regulated
- **Read the Label!**
- Situational
  - Weed species
  - Desirable species
  - Selective!
  - Site
- IPM
  - Part of program
  - Economics/feasibility
- Management to desirable state



Questions?

tjgetts@ucanr.edu
530-251-2650

Useful Websites/Sources

Organic Herbicide Information

Natural Herbicides: Are they effective? | UC Agriculture and Natural Resources

Can I Use Vinegar to Control Weeds? | UC Agriculture and Natural Resources

Green Bulletin Vol 13 Issue 1

UC Cooperative Extension studies organic herbicides for weed control in landscapes | UC Agriculture and Natural Resources

Capric Acid: A Promising Next-Generation Herbicide for Organic Specialty Crop Production – 0.314 - Extension

Organic Herbicides

Organic Herbicides | Arkansas Organic Ag

Corn Gluten Meal Profile

Useful Websites/Sources cnt.

Pollinator Pesticide Ratings

bee-precaution-pesticide-ratings / University of California Statewide Integrated Pest Management Program (UC IPM)

Glyphosate Information

greenbulletin.2019.fall.pdf

https://www.epa.gov/ingredients-used-pesticide-products/glyphosate

National Pesticide Information Center

https://npic.orst.edu/

Useful Websites/Sources cnt.

Herbicide Symptomology Information

Herbicides | UC Agriculture and Natural Resources

Calibration Training

https://ipm.ucanr.edu/training/index.html

https://ipm.ucanr.edu/training/incorporating-calibration.html

Weed Cut- For Natural Areas- But can be useful

- https://weedcut-new.ipm.ucanr.edu/

Useful Websites/Sources cnt.

Weed RIC

https://wric.ucdavis.edu/