Glyphosate – The World's Herbicide

Pros and Cons for Orchard Weed Management

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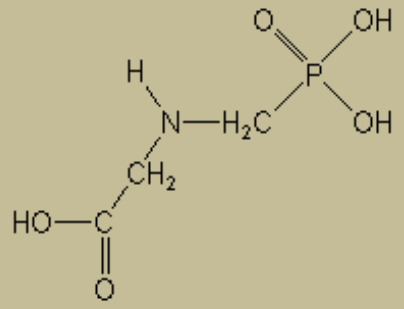
Tehama Prune Day
Red Bluff, CA
2-5-10

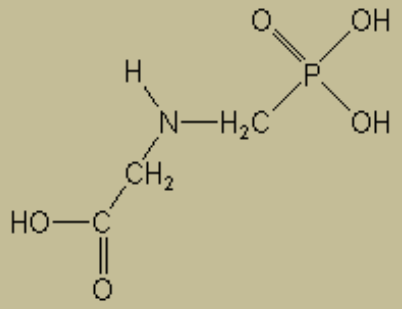
see Duke and Powles 2008.
Pest Manage. Sci 64:319-325

Glyphosate



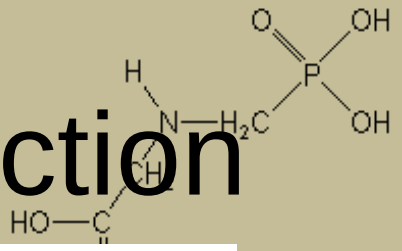
- N-(phosphonomethyl)glycine
- First tested and patented ~1970
  - IPA salt formulation released in 1974
- Foliar activity, no residual
- Translocated to growing points
- Broad weed control spectrum
  - Grasses, broadleaves, annuals, perennials, woody, aquatics

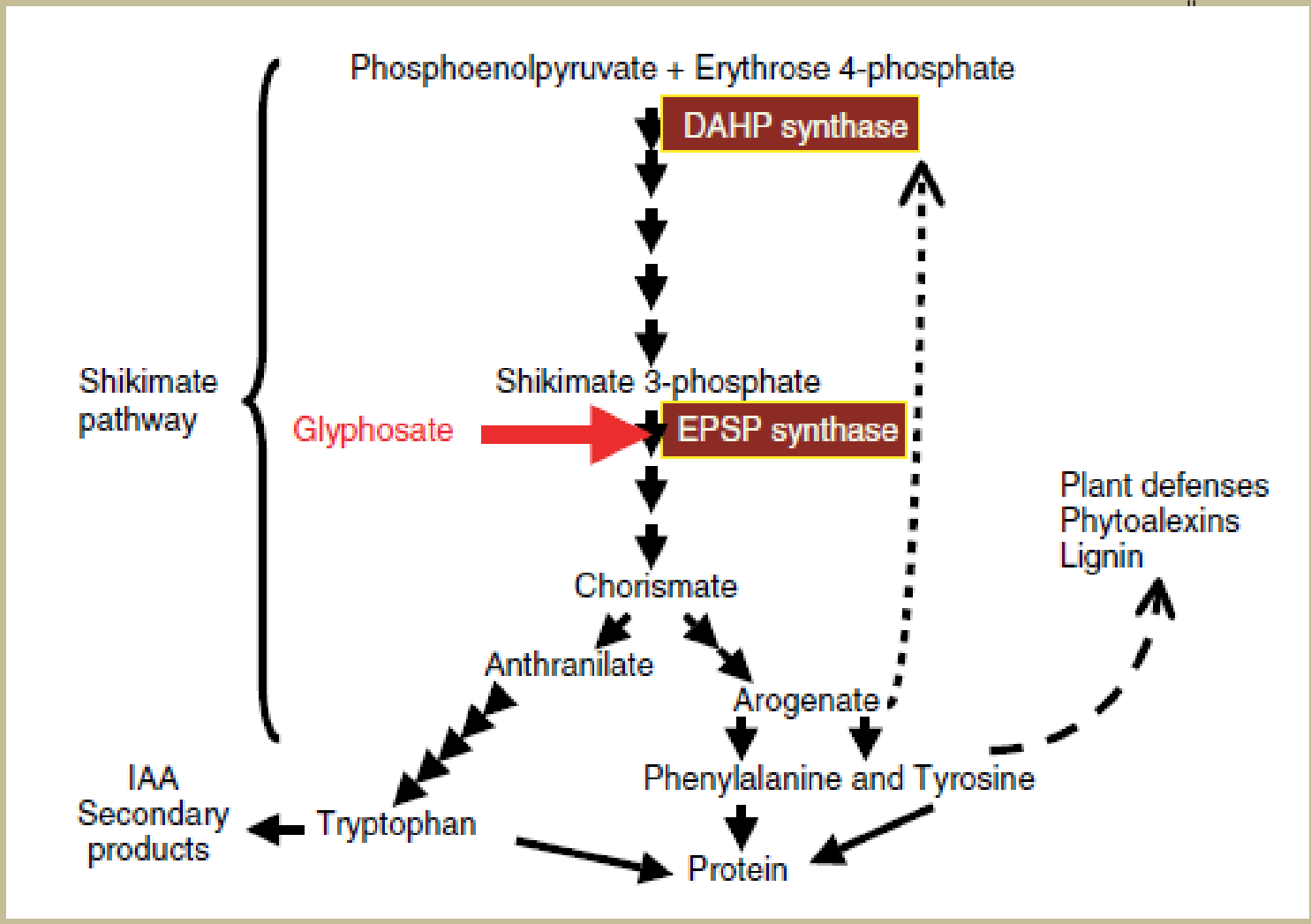
Most Widely Used Herbicide in the World



- Hundreds of labels
  - Preplanting in many annual crops
  - Post harvest or harvest aid
  - Directed applications in annuals and perennials
  - Non-crop areas
  - Aquatic weeds (no surfactants)
  - Homeowner products
  - Vegetation suppression
  - Etc.

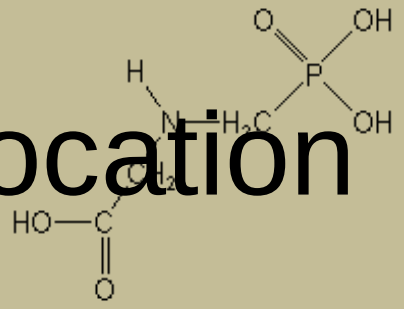
Pros – Unique Mode of Action





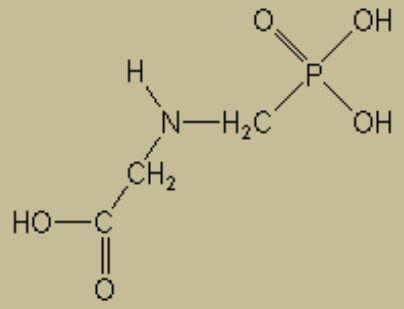
Duke and Powles 2008

Pros – Uptake and Translocation



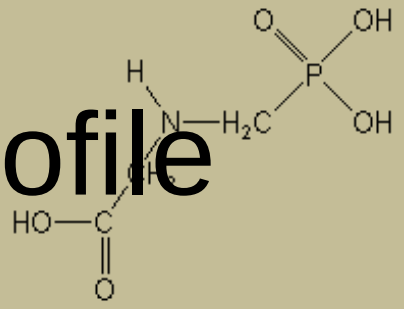
- Taken up rapidly through plant surfaces
  - Varies somewhat between species – susceptibility
- Quickly enters phloem via difusion
  - Translocated with photosynthates to meristematic regions
    - Meristems, young leaves, root tips, other actively growing tissues
- Very limited degradation in most plants

Pros – Low Toxicity

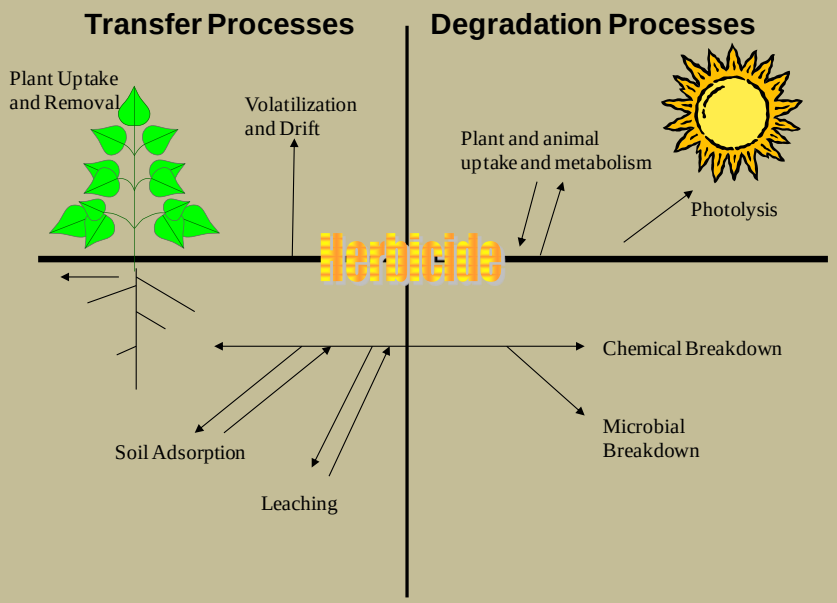


- Humans don't have the same target site as plants
- Very low mammalian toxicity
  - LD50 (rats) is 5 g / kg body weight
    - 175 lb person would have to ingest ~1 lb of glyphosate
    - 7.5-fold less toxic than aspirin
    - 14-fold less toxic than nicotine
  - In most formulations, the surfactants are more toxic than the glyphosate
  - Not a carcinogen or reproductive hazard

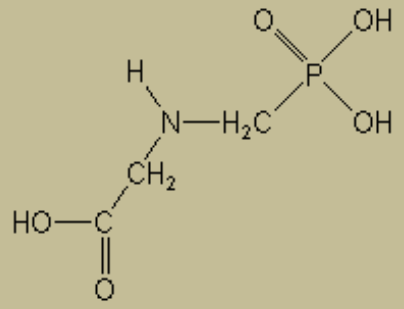
Pros – Environmental Profile



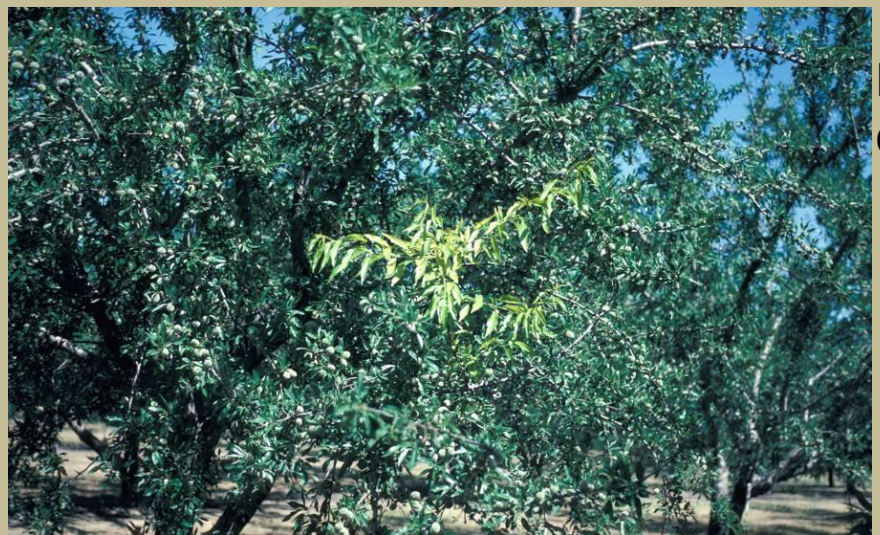
- Generally benign in the environment
  - Binds tightly to soil – so little groundwater issues
  - Relatively short half-life due to microbial activity
  - This is why glyphosate is always applied to foliage



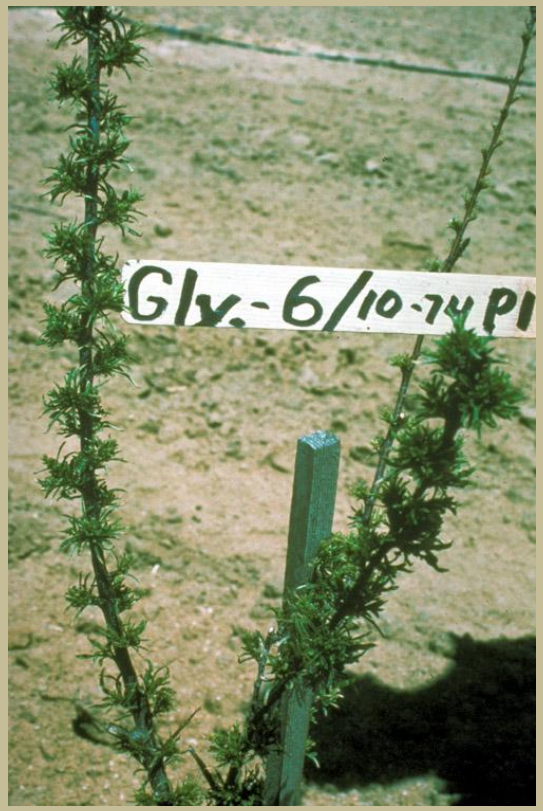
Cons – Drift risks



- Glyphosate not more prone to drift
- However…
  - Active at low rates
  - Translocated to growing points
  - Slow degradation in plants

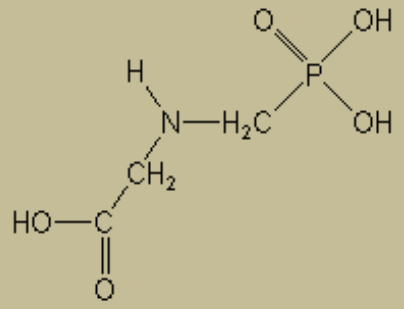


Drift
on almond



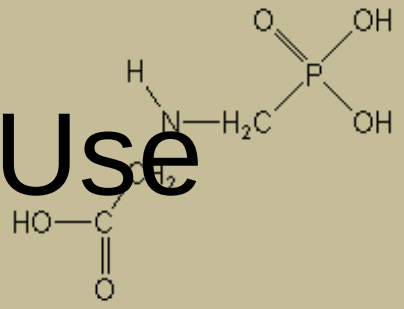
Simulated drift on plum

Cons - Overreliance



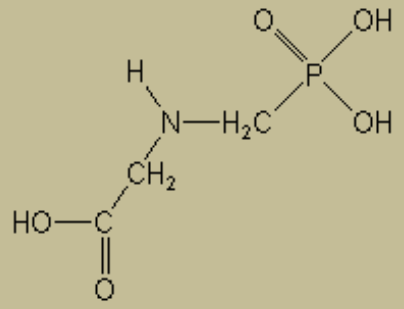
- Easy, effective, economical, broad spectrum,, applicator and environmental safety…
- Often can lead to overreliance and associated problems

Changes in Glyphosate Use



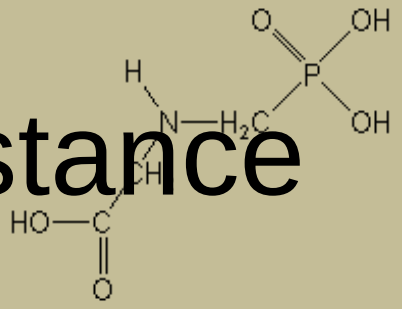
- Adoption of RR crops (early 90's)
  - Corn, soybean, cotton, canola, alfalfa
  - Sugarbeet, wheat, bentgrass
- Increasing dependence on glyphosate in CA
  - RoundUp off patent in 2000 – price decrease
  - GWPA
  - Growers switching to POST weed management
    - 81% stonefruit acres in 2002; 110% in 2007
    - 116% tree nut acres in 2002; 144% in 2007

Cons - Weed Shifts

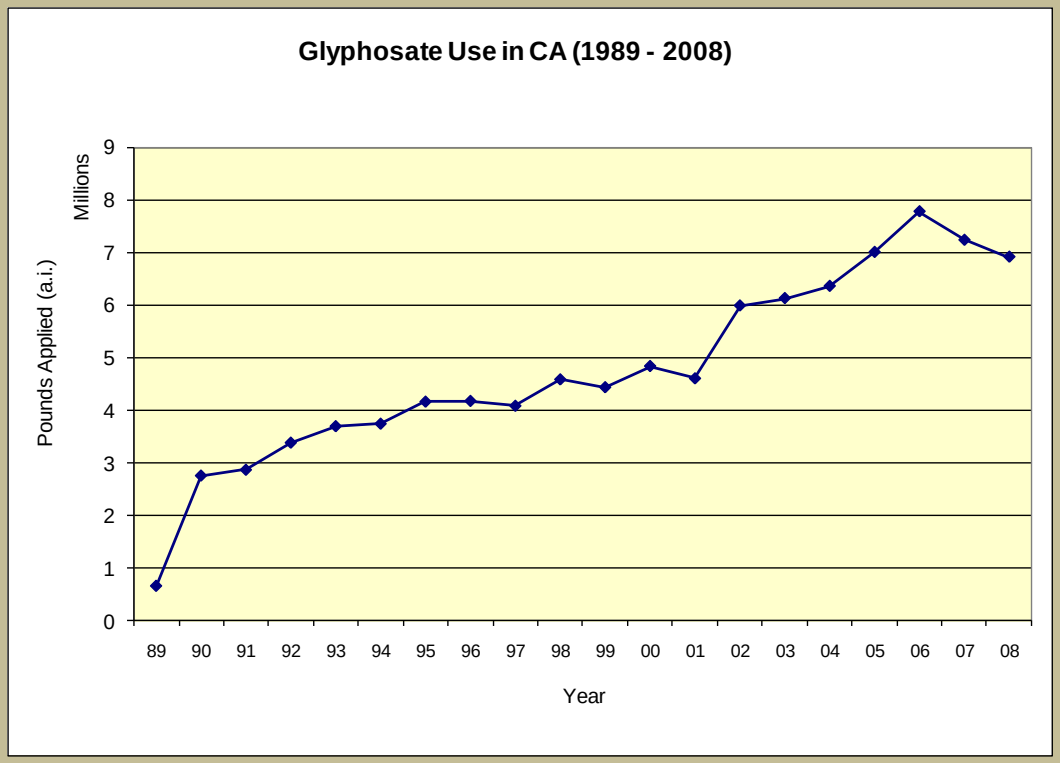


- Glyphosate is BROAD spectrum but not COMPLETE spectrum
  - Some species not well controlled
    - Some pigweeds, lambsquarters, morninglories, etc
- Dependence on glyphosate has resulted in many crops changing to a POST only program
  - Especially in RoundUp Ready crops
    - No-till
  - Also in tree and vine crops

Cons – Selection for Resistance

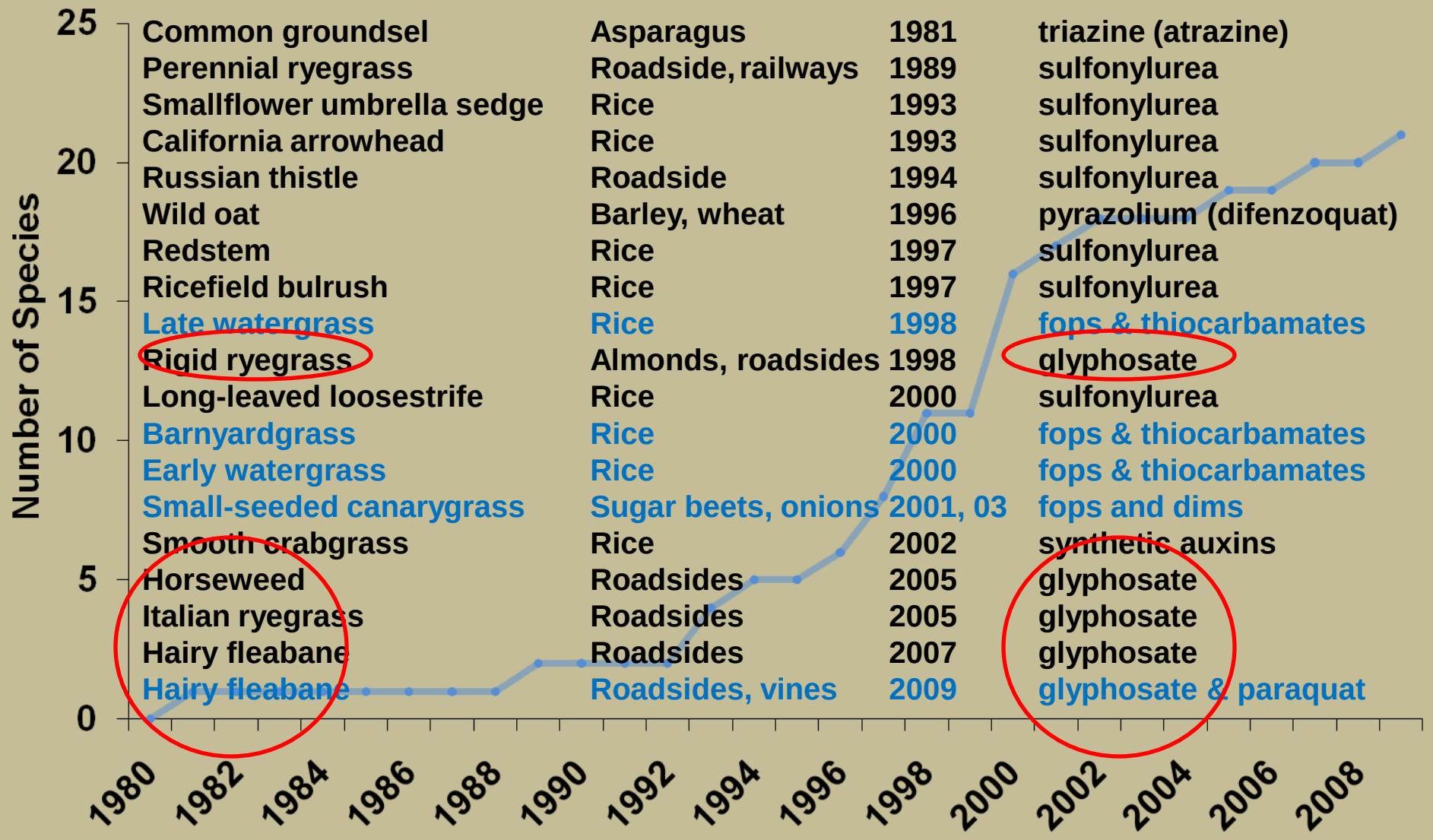


- Repeated use can select for resistant biotypes
  - Any herbicide or other weed management tool



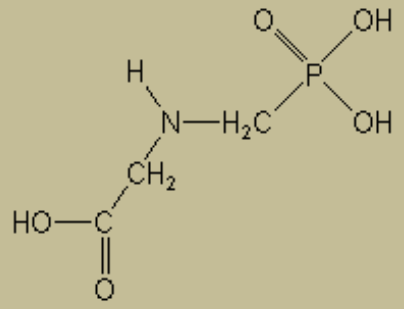
~41% of all herbicides in CA

HRW in California



Common groundsel	Asparagus	1981	triazine (atrazine)
Perennial ryegrass	Roadside, railways	1989	sulfonylurea
Smallflower umbrella sedge	Rice	1993	sulfonylurea
California arrowhead	Rice	1993	sulfonylurea
Russian thistle	Roadside	1994	sulfonylurea
Wild oat	Barley, wheat	1996	pyrazolium (difenzoquat)
Redstem	Rice	1997	sulfonylurea
Ricefield bulrush	Rice	1997	sulfonylurea
Late watergrass	Rice	1998	fops & thiocarbamates
Rigid ryegrass	Almonds, roadsides	1998	glyphosate
Long-leaved loosestrife	Rice	2000	sulfonylurea
Barnyardgrass	Rice	2000	fops & thiocarbamates
Early watergrass	Rice	2000	fops & thiocarbamates
Small-seeded canarygrass	Sugar beets, onions	2001, 03	fops and dims
Smooth crabgrass	Rice	2002	synthetic auxins
Horseweed	Roadsides	2005	glyphosate
Italian ryegrass	Roadsides	2005	glyphosate
Hairy fleabane	Roadsides	2007	glyphosate
Hairy fleabane	Roadsides, vines	2009	glyphosate & paraquat

What's Next?



- What are we "selecting" with our weed management strategies?
  - Common weeds – prone to resistance
  - Important herbicides use and reliance trends
  - Agronomic actions
    - Perennial crops, specialty crops, reduced tillage

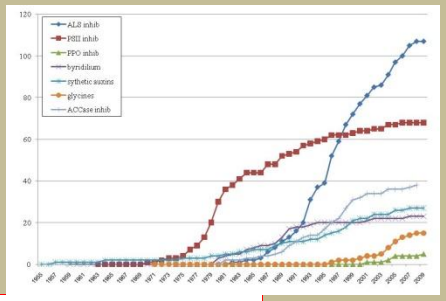
Carnac the Magnificent by Johnny Carson

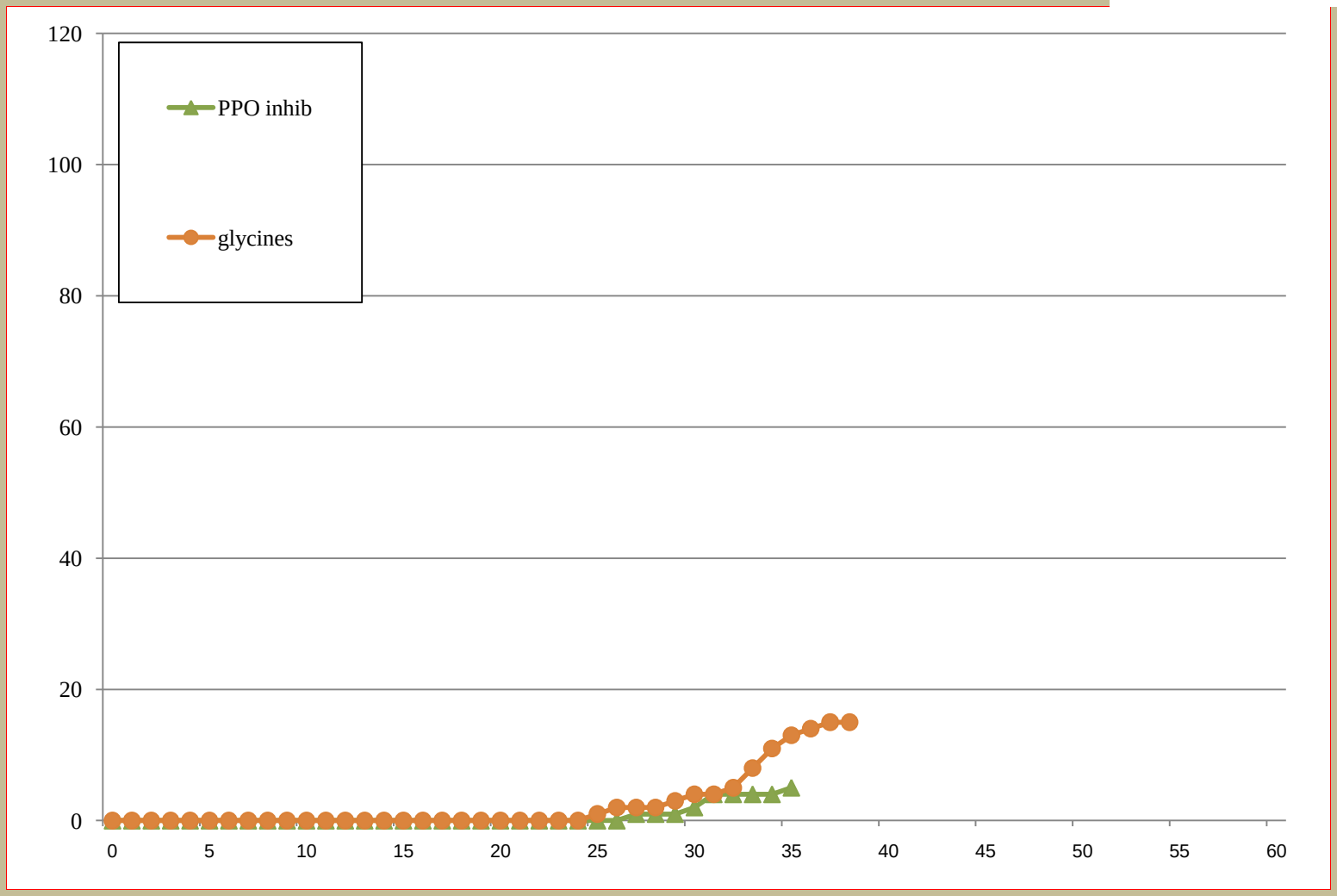
Worst HRW Worldwide (# infested sites)

	Present in CA	Resistance outside CA	Resistance reported in CA
Rigid ryegrass	☑	8 modes of action	☑ glyphosate
Wild oat	☑	6 MOA	☑ difenzoquat
Redroot pigweed	☑	3 MOA	
Common lambsquarters	☑	4 MOA	
Green foxtail	☑	4 MOA	
Barnyardgrass	☑	7 MOA	☑ ACCase, thiocarbamates
Goosegrass	☑	4 MOA	
Kochia	☑	3 MOA	
Horseweed	☑	5 MOA	☑ glyphosate, paraquat
Smooth pigweed	☑	2 MOA	

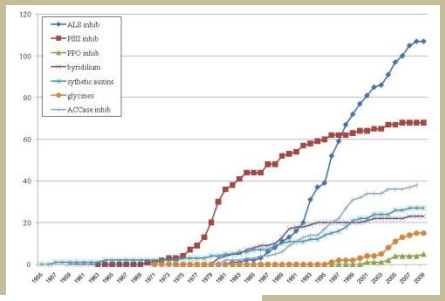
10 worst weeds from www.weedscience.org

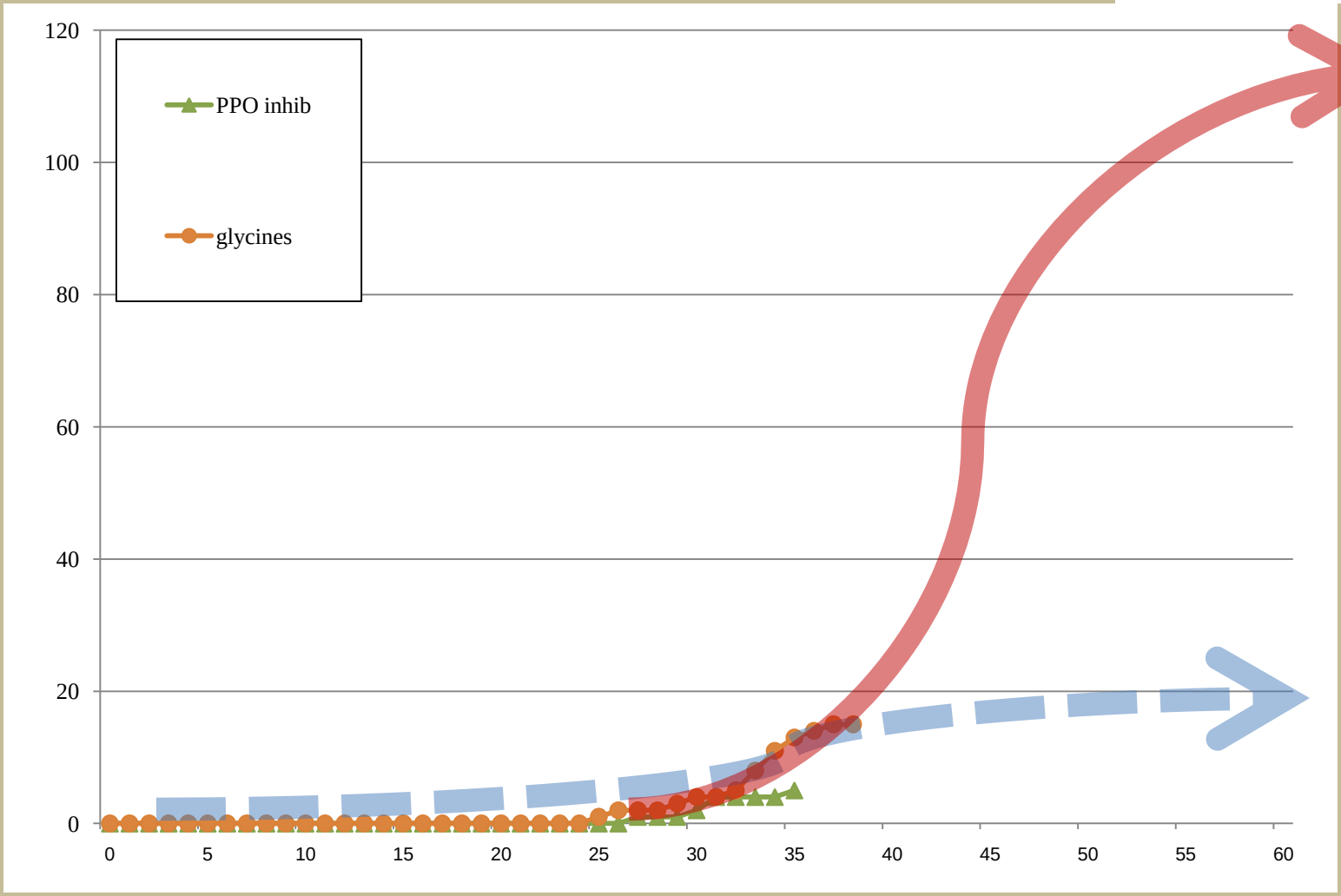
Resistance Trends





The Future?


ALS inhib
PSII inhib
PPO inhib
pyridium
sythetic auxins
glycines
ACCase inhib


PPO inhib
glycines
120
100
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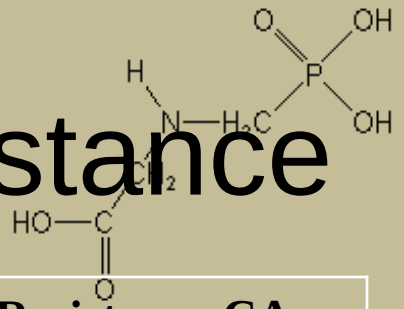
60

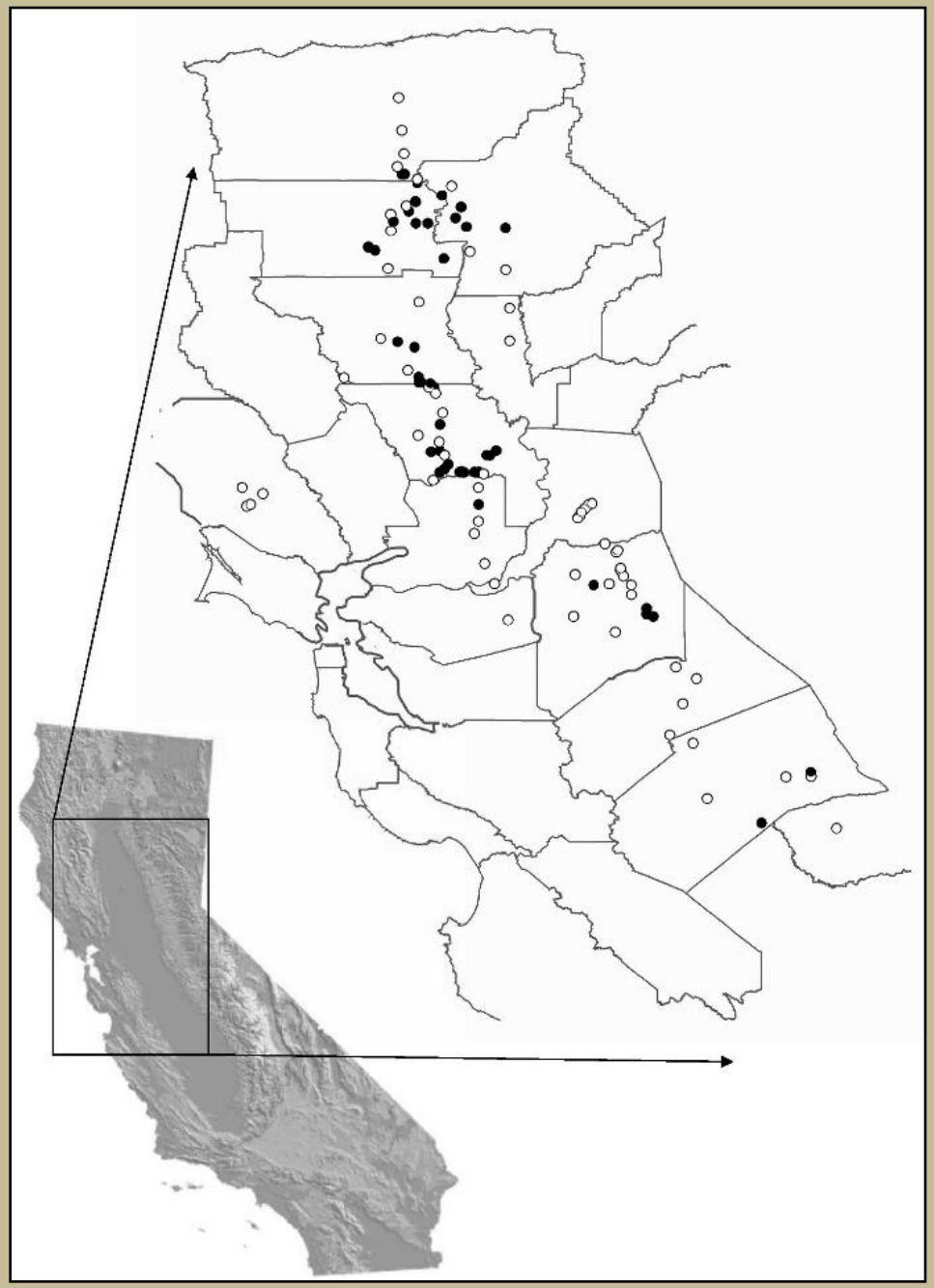
Reported Glyphosate Resistance



	Resistance USA	Resistance CA
Amaranthus palmeri, A. rudis)	☑ ☑	
Ambrosia artemisifolia, A. trifada	☑ ☑	
Conyza bonariensis, C. canadensis	☑ ☑	☑ ☑
Digitaria insularis		
Echinochloa colona		
Eleusine indica		
Euphorbia heterophylla		
Lolium multiflorum, L. rigidum	☑ ☑	☑ ☑
Parthinium hysterophorus		
Plantago lanceolata		
Sorghum halapense	☑	
Urochloa panicoides		

Rigid and Italian Ryegrass
(*Lolium rigidum* and *L. multiflorum*)

- Often co-exist (swarm)
- Annual grass
- Obligate outcrossers
- Throughout CA but more common weed in northern Central Valley
- 2 to 15-fold resistance
- Usually target site mutation



Italian Ryegrass

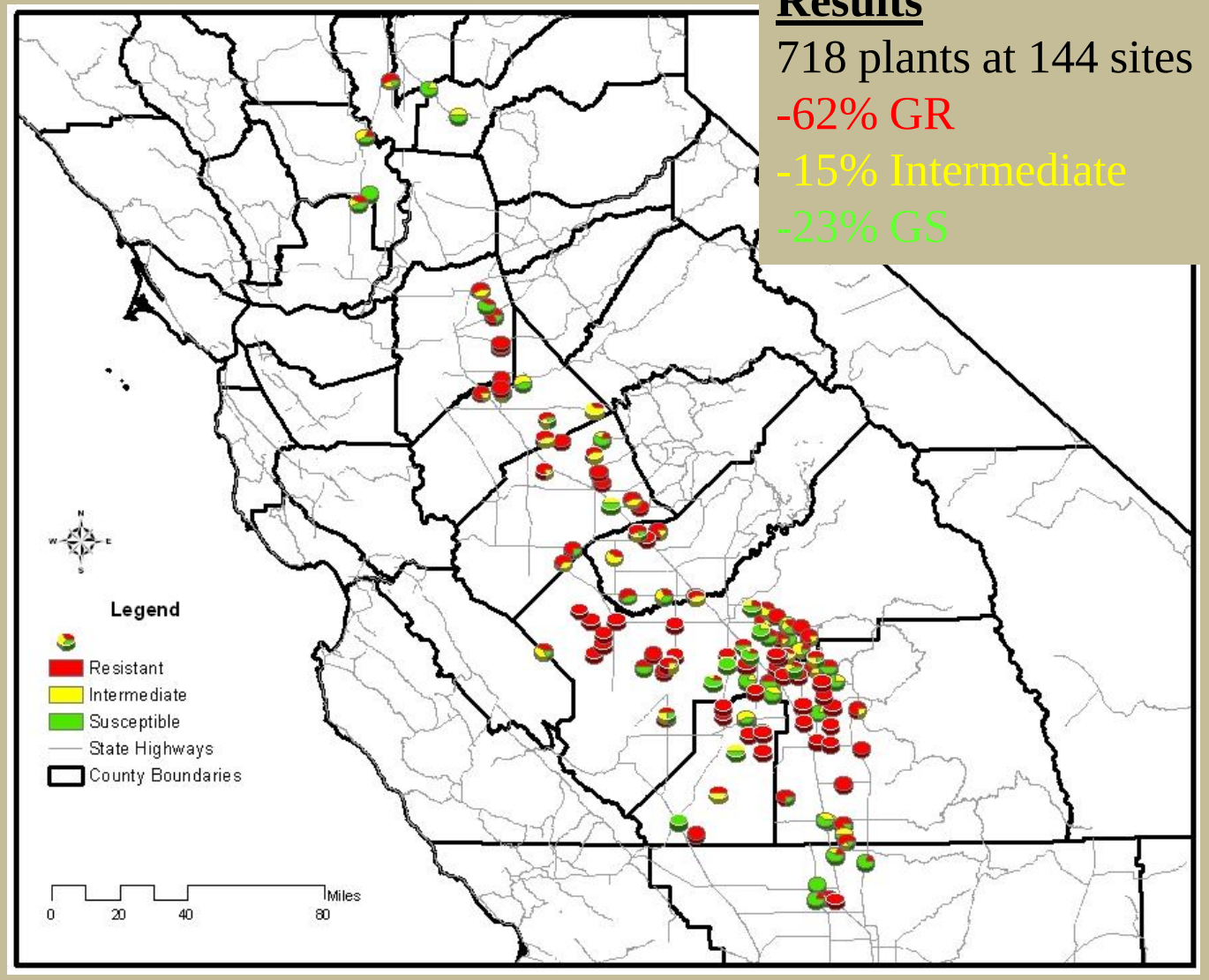
Figure 1. Map of California showing the geographical distribution of Italian ryegrass populations sampled for this study. Closed circles indicate populations with more than 20% seedlings surviving treatment with glyphosate t 866 g ae / ha; open circles indicate populations with 5% (two populations) or no surviving seedlings. Forty seedlings from each population were tested for glyphosate response.

From Jasieniuk et al. 2008.
Weed Sci 56:496-502

Horseweed (*Conyza canadensis*)

- AKA mare's tail
- Annual weed
- Prolific seed producer
- Wind-blown seed
- Early colonizer
- Doesn't tolerate disturbance
- 6-fold resistance (whole plant)
- 4-8 fold resistance (in vivo)
- Mechanism not know. Suspected translocation mutation

Horseweed Survey – 2006-07



Results

718 plants at 144 sites

-62% GR

-15% Intermediate

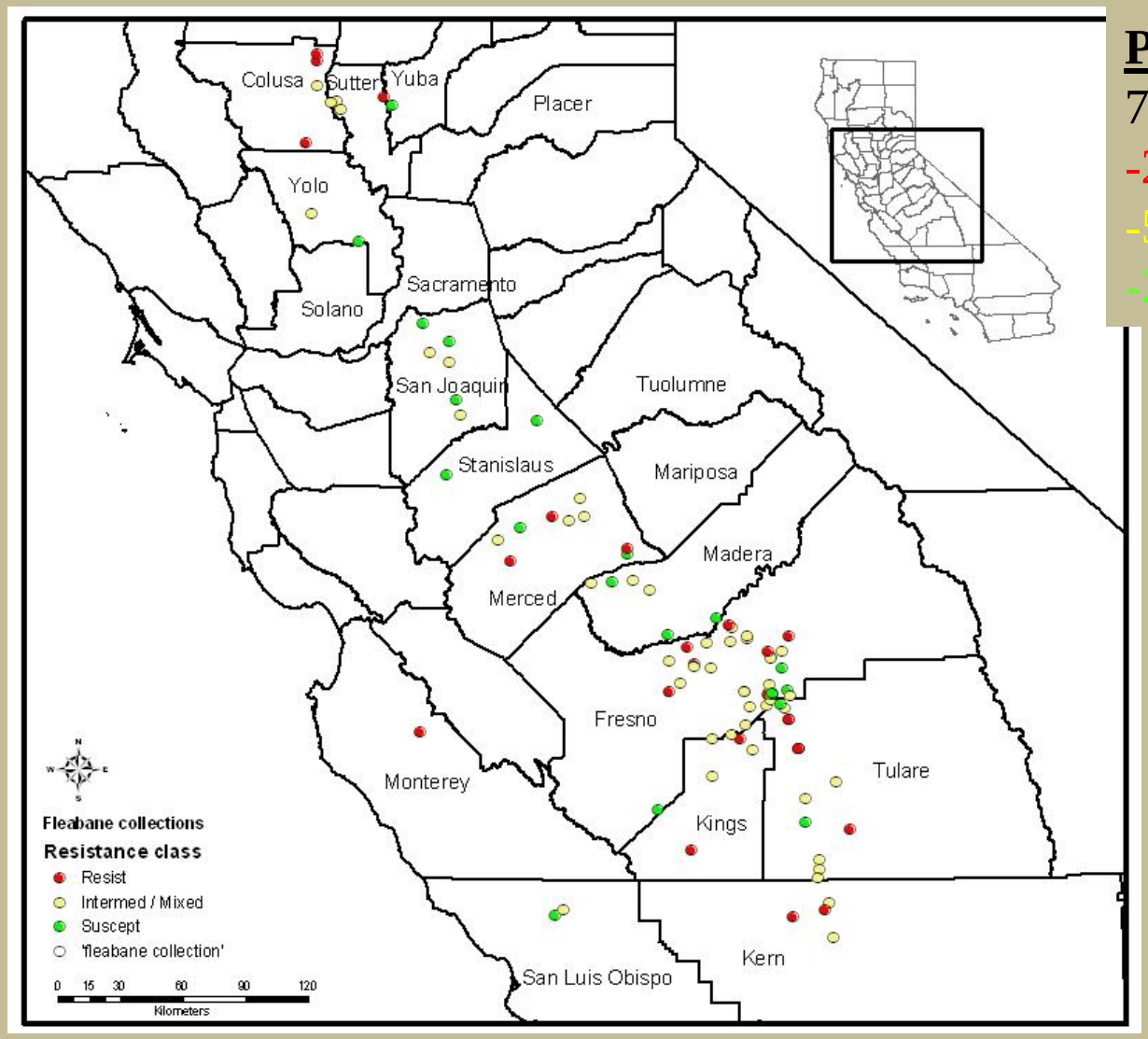
-23% GS

Hanson et al. 2009
Weed Sci 57:48-53

Hairy Fleabane (*C. bonariensis*)

- AKA flaxleaf fleabane
- Annual weed
- Wind-blown seed
- Early colonizer
- Doesn't tolerate disturbance
- 3 to 10-fold resistance (whole plant screening)
- ~ 4-fold resistance in vivo
- Mechanism not known

Hairy Fleabane Survey - 2009



Prelim Results

75 populations

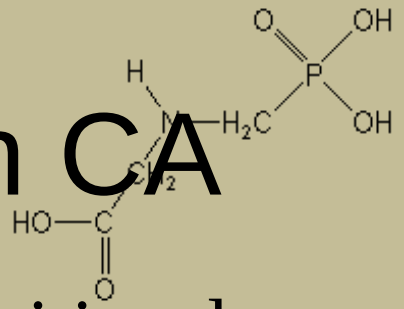
-27% GR

-52% Mixed

-21% GS

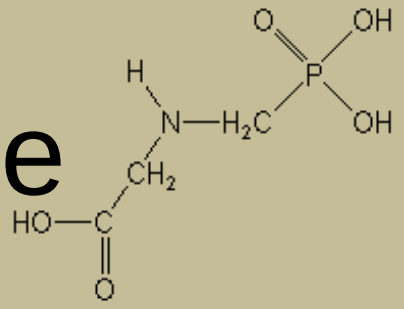
Zozaya et al. 2010
CWSS poster session

Weeds of GR Concern in CA

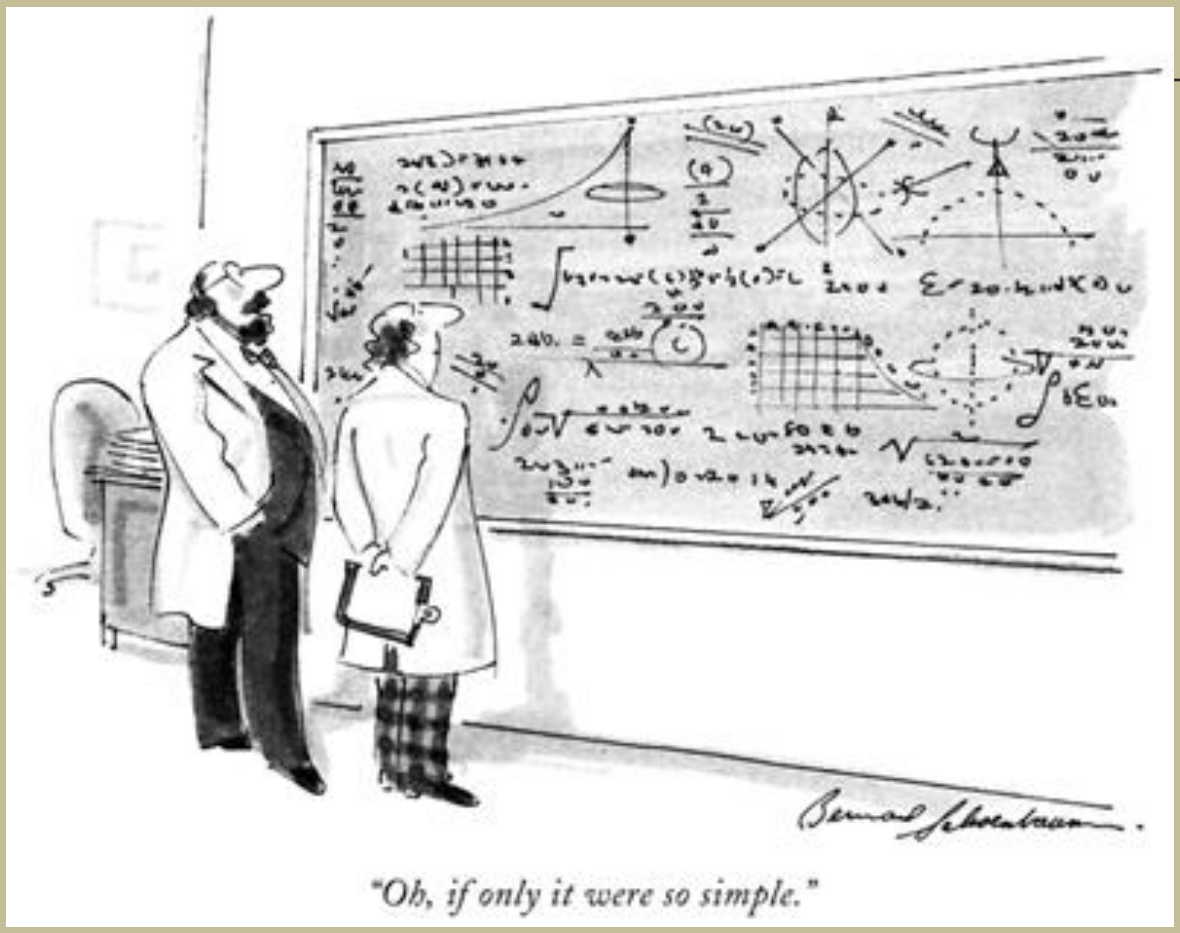


- Cooperative research project recently initiated
  - UCD, UCCE, CSUF
- Focus on screening, quantifying, and mapping, and identifying mechanisms of resistance in:
  - Junglerice (*Echinochloa colona*)
  - Barnyardgrass (*Echinochloa crus-galli*)
  - Common lambquarters (*Chenopodium album*)
  - Johnsongrass (*Sorghum halepense*)
  - Pigweeds (*Amaranthus* spp.)
    - 11 pigweed species with resistance, 7 different MOA

Preserving Glyphosate



- Need to diversify weed management to preserve glyphosate as a tool
  - Genetics? Probably not soon in tree crops
  - New herbicides? A few new products coming
  - Use PRE products in addition to POST
  - Alternate or combine POST materials
  - Use full rates
  - Mechanical (tillage, mowing, mulches?)



"Oh, if only it were so simple."