



Pesticide Application: Issues and Critical Aspects

2018 New Mexico Vegetation
Management Association Meeting

Albuquerque, New Mexico

November 14, 2018

Pesticide Application: Critical Aspects and Issues

- Topics for Consideration:
 - Industry Changes
 - Label Changes
 - Drift Management
 - Dicamba-tolerant
 - Water Quality
 - Herbicide Resistance



MONSANTO



02 AI AIC AIXR TT TTI XR XRC (50) AI3070 AITTJ60 TTJ60 (100)	20	F	VC	C	VC	XC	XC	—	UC	0.14
	30	F	C	C	VC	VC	VC	UC	UC	0.17
	40	F	M	M	C	C	C	XC	UC	0.20
	50	F	M	M	C	C	C	XC	UC	0.22
	60	F	M	M	M	M	C	VC	UC	0.24
	70	—	F	M	M	M	M	VC	XC	0.26
	80	—	F	M	M	M	M	VC	XC	0.28
025 AI AIC AIXR TT TTI XR XRC (50) AI3070 AITTJ60 TTJ60 (100)	90	—	F	M	M	F	M	VC	XC	0.30
	20	M	VC	VC	XC	XC	XC	—	UC	0.18
	30	F	C	C	VC	VC	VC	UC	UC	0.22
	40	F	M	M	C	C	C	XC	UC	0.25
	50	F	M	M	C	C	C	XC	UC	0.28
	60	F	M	M	C	C	C	XC	UC	0.31
	70	—	F	M	C	M	M	VC	XC	0.33
03 AI AIC AIXR AITTJ60 AI3070 TT TTI XR XRC (50) TTJ60 (100)	80	—	F	M	C	M	M	VC	XC	0.35
	90	—	F	M	M	M	M	VC	XC	0.38
	20	M	VC	VC	XC	UC	UC	—	UC	0.21
	30	F	C	C	VC	VC	VC	XC	UC	0.26
	40	F	C	C	VC	VC	VC	XC	UC	0.30
	50	F	M	M	C	C	C	VC	UC	0.34
	60	F	M	M	C	C	C	VC	UC	0.37
04 AI AIC AITTJ60 AIXR AI3070 TT TTI TTJ60 XR XRC (50)	70	—	M	M	C	C	C	VC	UC	0.40
	80	—	M	M	C	C	C	VC	UC	0.42
	90	—	F	M	M	M	M	VC	XC	0.45
	20	M	VC	VC	XC	UC	UC	—	UC	0.28
	30	M	C	C	XC	XC	XC	UC	UC	0.35
	40	M	C	C	VC	VC	VC	XC	UC	0.40
	50	F	M	M	C	VC	VC	VC	UC	0.45
	60	F	M	M	C	VC	VC	VC	UC	0.49
	70	—	M	M	C	C	C	VC	UC	0.53
	80	—	M	M	C	C	M	VC	XC	0.57
	90	—	M	M	C	C	M	VC	XC	0.60

Pesticide Application: Critical Aspects and Issues

SPRAY DRIFT MANAGEMENT

A variety of factors including weather conditions (e.g., wind direction, wind speed, temperature, relative humidity) and method of application (e.g., ground, aerial, airblast, chemigation) can influence pesticide drift. The applicator must evaluate all factors and make appropriate adjustments when applying this product.

Droplet Size

When applying sprays that contain 2,4-D as the sole active ingredient, or when applying sprays that contain 2,4-D mixed with active ingredients that require a coarse or coarser spray, apply only as a coarse or coarser spray (ASAE standard 572) or a volume mean diameter of 385 microns or greater for spinning atomizer nozzles.

When applying sprays that contain 2,4-D mixed with other active ingredients that require a medium or more fine spray, apply only as a medium or coarser spray (ASAE standard 572) or a volume mean diameter of 300 microns or greater for spinning atomizer nozzles.

Wind Speed

Do not apply at wind speeds greater than 15 mph. Only apply this product if the wind direction favors on-target deposition and there are not sensitive areas (including, but not limited to, residential areas, bodies of water, known habitat for nontarget species, nontarget crops) within 250 feet downwind. If applying a medium spray, leave one swath unsprayed at the downwind edge of the treated field.

Temperature Inversions

If applying at wind speeds less than 3 mph, the applicator must determine if: a) conditions of temperature inversion exist, or b) stable atmospheric conditions exist at or below nozzle height. Do not make applications into areas of temperature inversions or stable atmospheric conditions.

2,4-D Granules

A selective weed killer

For control of broadleaf weeds and certain seedling grasses.

ACTIVE INGREDIENT:

Isooctyl (2-ethylhexyl) Ester of 2,4-Dichlorophenoxyacetic Acid*28.9%

OTHER INGREDIENTS: 71.1%

TOTAL:100.0%

Isomer Specific AOAC Method, Equivalent to:

*2,4-Dichlorophenoxyacetic Acid19.18%



AMINE 4 2,4-D WEED KILLER

GROUP 4 HERBICIDE

For Selective Broadleaf Weed Control in Certain Crops, Turf and Non-Crop Areas.

ACTIVE INGREDIENT:

*Dimethylamine salt of 2,4-Dichloro-phenoxyacetic acid 46.5%

OTHER INGREDIENTS: 53.5%

TOTAL100.0%

*Equivalent to 38.6% 2,4-D acid or 3.74 pounds per gallon.

*Isomer specific by AOAC Method No. 6.275-6.279 (13th Ed.)



Pesticide Application: Critical Aspects and Issues

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Droplet Size

When applying sprays that contain 2,4-D as the sole active ingredient, or when applying sprays that contain 2,4-D mixed with active ingredients that require a Coarse or coarser spray, apply only as a Coarse or coarser spray (ASAE standard 572) or a volume mean diameter of 385 microns or greater for spinning atomizer nozzles.

When applying sprays that contain 2,4-D mixed with other active ingredients that require a Medium or more fine spray, apply only as a Medium or coarser spray (ASAE standard 572) or a volume mean diameter of 300 microns or greater for spinning atomizer nozzles.



Pesticide Application: Critical Aspects and Issues

MANAGEMENT OF SPRAY DRIFT

- Use coarse sprays (volume median diameter of 400 microns or more) to avoid potential herbicide drift. Select nozzles that are designed to produce minimal amounts of fine spray particles (less than 200 microns). Examples of nozzles designed to produce coarse sprays via ground applications are Delavan® Raindrops, Spraying Systems XR (excluding 110° tips) flat fans, Turbo Teejets®, Turbo Floodjets® or large capacity flood nozzles such as D10, TK10 or greater capacity tips.
- Keep the spray pressure at or below 20 psi and the spray volume at or above 20 gallons per acre (for ground broadcast applications), unless otherwise required by the manufacturer of drift-reducing nozzles. Consult your spray nozzle supplier concerning the choice of drift-reducing nozzles.
- Agriculturally approved drift-reducing additives may be used.

Pesticide Application: Critical Aspects and Issues

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Table 2. Droplet size distribution classification (ASABE Standard S572.1). These colors can be found in nozzle literature and labels, but are different from nozzle tip colors.

Droplet Category	Symbol	Color Code	VMD Range (microns)*
Extremely Fine	XF	Purple	< 60
Very Fine	VF	Red	61–144
Fine	F	Orange	144–235
Medium	M	Yellow	236–340
Coarse	C	Blue	341–403
Very Coarse	VC	Green	404–502
Extremely Coarse	XC	White	503–665
Ultra Coarse	UC	Black	> 665

“VMD” = Volume Mean Diameter

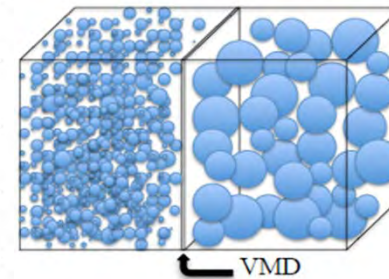


Figure 1. VMD is the droplet size at which 50% of the spray volume is in droplets larger than the VMD and 50% of the volume is in droplets smaller than the VMD (adapted from Matthews 1992).

XR8004	15	C	M	0.24
XR11004	20	M	M	0.28
(50)	30	M	M	0.35
	40	M	M	0.40
	50	F	F	0.45
	60	F	F	0.49

Pesticide Application: Critical Aspects and Issues

MANAGEMENT OF SPRAY DRIFT

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- Agriculturally approved drift-reducing additives may be used.

MIXING ORDER

1. Water - Begin by agitating a thoroughly clean sprayer tank three-quarters full of clean water.
 2. Agitation - Maintain constant agitation throughout mixing and application.
 3. Inductor - If an inductor is used, rinse it thoroughly after each component has been added.
 4. Products in PVA bags - Place any product contained in water-soluble PVA bags into the mixing tank. Wait until all water-soluble PVA bags have fully dissolved and the product is evenly mixed in the spray tank before continuing.
 5. Water-dispersible products (dry flowables, wettable powders, suspension concentrates or suspo-emulsions).
 6. Water-soluble products (such as this product).
 7. Emulsifiable concentrates (such as oil concentrate when applicable).
 8. Water-soluble additives (such as AMS or UAN when applicable).
 9. Remaining quantity of water.
- Maintain constant agitation during application.

ADDITIVES

To improve post-emergence weed control, agriculturally approved surfactants, sprayable fertilizers (Urea Ammonium Nitrate or Ammonium Sulfate) or crop oil concentrate may be added particularly in dry growing conditions. (Refer to **TABLE 3**).

Nitrogen Source

- Urea Ammonium Nitrate (UAN): Use 2 to 4 quarts of UAN (commonly referred to as 28%, 30% or 32% Nitrogen solution) per acre. Do not use brass or aluminum nozzles when spraying UAN.
- Ammonium Sulfate (AMS): AMS at 2.5 pounds per acre may be substituted for UAN. Use high-quality AMS (spray grade) to avoid plugging of nozzles. Other sources of Nitrogen are not as effective as those mentioned. Manufacturer does not recommend applying AMS if applied in less than 10 gallons per acre because of potential problems with precipitation in reduced volumes. Use AMS only if it has been demonstrated to be successful in local experience.

Pesticide Application: Critical Aspects and Issues

Banvel® Herbicide

PEEL HERE
TO OPEN

FOR WEED CONTROL IN CORN, SORGHUM, SMALL GRAINS,
PASTURE, HAY, RANGELAND, FARMSTEAD (NON-CROPLAND), FALLOW,
SUGARCANE, ASPARAGUS, TURF AND GRASS SEED CROPS.

ACTIVE INGREDIENT	By Weight
Dimethylamine salt of dicamba (3,6-dichloro-o-anisic acid)*	49.4%
OTHER INGREDIENTS	50.6%
TOTAL	100.0%

* This product contains 41.0% 3,6-dichloro-o-anisic acid (dicamba) or 4 pounds per gallon (480 g/L).

KEEP OUT OF REACH OF CHILDREN CAUTION/PRECAUCIÓN

Si usted no entiende la etiqueta, 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.)

See inside of booklet for complete Precautionary Statements and Directions For Use.

Manufactured for:
ARYSTA LIFESCIENCE NORTH AMERICA, LLC
15401 Weston Parkway, Suite 150
Cary, North Carolina 27513

EPA Registration No. 66330-276
EPA Establishment No. 68323-TX-001

For Product Information: 1-866-761-9397

AD091109
2040549—081110

Clarity® herbicide

For weed control in asparagus, conservation reserve programs, corn, cotton, fallow croplands, general farmstead (noncropland), sorghum, grass grown for seed, hay, proso millet, pasture, rangeland, small grains, sod farms and farmstead turf, soybean, and sugarcane.

Active Ingredient:	
Diglycolamine salt of 3,6-dichloro-o-anisic acid*	58.1%
Other Ingredients:	41.9%
Total	100.0%

*Contains 39.4% 3,6-dichloro-o-anisic acid (4 pounds acid equivalent per gallon or 480 grams per liter).

EPA Reg No. 7969-137

EPA Est. No.

KEEP OUT OF REACH OF CHILDREN CAUTION/PRECAUCIÓN

Si usted no entiende la etiqueta, 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.)

See inside booklet for complete **First Aid, Precautionary Statements, Directions For Use, State-Specific Crop and/or Use Site Restrictions and Conditions of Sale and Warranty.**

In case of an emergency endangering life or property involving this product, call day or night 1-800-832-HELP (4357).

Net Contents:

BASF Corporation
26 Davis Drive, Research Triangle Park, NC 27709

Pesticide Application: Critical Aspects and Issues

GROUP 4 HERBICIDE

Drexel.

Dicamba DGA

Herbicide

For weed control in Asparagus, Conservation Reserve Programs, Corn, Cotton, Fallow croplands, General farmstead (Non-cropland), Grass grown for seed, Hay, Pasture, Proso millet, Rangeland, Small grains, Sod farms and Farmstead turf, Sorghum, Soybeans and Sugarcane.

ACTIVE INGREDIENT:

Diglycolamine salt of Dicamba..... 58.1%

OTHER INGREDIENTS: 41.9%

TOTAL: 100.0%

This product contains 39.4% of Dicamba equivalent to 4 pounds per gallon or 480 grams per liter.

PRECAUTIONARY STATEMENTS (Cont.)

See "ENGINEERING CONTROLS" for additional requirements. Follow the manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry.

ENGINEERING CONTROLS:

When handlers use closed systems or enclosed cabs in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240(d)(4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

Pesticide Application: Critical Aspects and Issues



Palmer Amaranth –
Amaranthus palmeri



EPA Registers Dicamba Formulation for Use on Dicamba Tolerant Crops

For Release: November 9, 2016

EPA is registering a dicamba formulation, Xtendimax™ with Vapor Grip™ Technology, which is specifically designed to have lower volatility, to control weeds in cotton and soybean crops genetically engineered to tolerate dicamba.

This registration is for a formulation of dicamba that contains an additive that reduces volatility. This formulation is different from the products that are alleged to have been recently used illegally. [EPA continues to investigate these issues in several locations](#) in the Midwest.

The label requires very specific and rigorous drift mitigation measures. Restrictions on the use of the product to further reduce the potential for exposure from spray drift include: no application from aircraft; no application when wind speed is over 15 mph; application only with approved nozzles at specified pressures; and buffer zones to protect sensitive areas when the wind is blowing toward them.

Pesticide Application: Critical Aspects and Issues



Bob Scott, a weed scientist at the University of Arkansas, says he wishes more testing could have been done on the new dicamba formulations, but "the product was not made available to us."

Dan Charles/ NPR

TOLERANT SOYBEAN TECHNOLOGY IS IN TROUBLE

DICAMBA IS MOVING OFF-TARGET IN
REGIONS LIKE MISSOURI'S
BOOTHEEL.

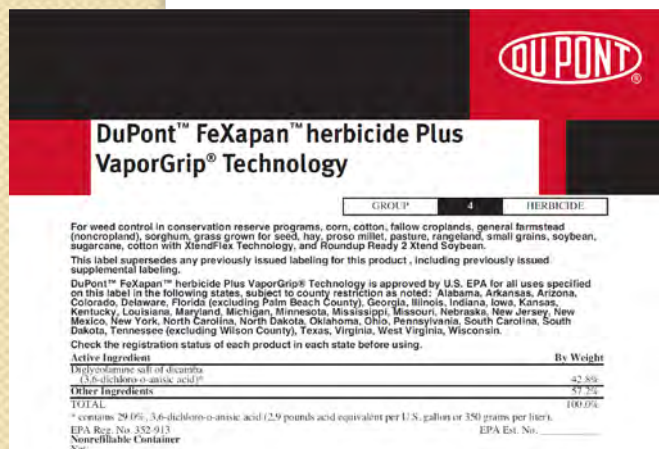
By [Gil Gullickson](#)
7/11/2017

A couple weeks ago, Kevin
Bradley came to the
intersection of U.S. Route
60 and Missouri Route 25



After the injury, newly grown soybean trifoliates will show signs of cupping, as the leaf puckers and the edges curl upwards.

Pesticide Application: Critical Aspects and Issues



For weed control in conservation reserve programs, corn, cotton, fallow croplands, general farmstead (noncropland), sorghum, grass grown for seed, hay, proso millet, pasture, rangeland, small grains, soybean, sugarcane, cotton with XtendFlex Technology, and Roundup Ready 2 Xtend Soybean.

This label supersedes any previously issued labeling for this product, including previously issued supplemental labeling.

DuPont™ FeXapan™ herbicide Plus VaporGrip® Technology is approved by U.S. EPA for all uses specified on this label in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin.

Check the registration status of each product in each state before using.

RESTRICTED USE PESTICIDE

For retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.

This labeling expires on 11/09/2018, unless the U.S. EPA determines before that date that off-site incidents are not occurring at unacceptable frequencies or levels. Do not use or distribute this product after 11/09/2018, unless you visit www.fexapanapplicationrequirements.dupont.com and can verify that EPA has amended this expiration date.

Active Ingredient	By Weight
Diglycolamine salt of dicamba (3,6-dichloro-o-anisic acid)*	42.8%
Other Ingredients	57.2%
TOTAL	100.0%

* contains 29.0% 3,6-dichloro-o-anisic acid (2.9 pounds acid equivalent per U.S. gallon or 350 grams per liter).

EPA Reg. No. 352-913

EPA Est. No. _____

Nonrefillable Container

Net: _____

Pesticide Application: Critical Aspects and Issues



This labeling expires on 11/09/2018, unless the U.S. EPA determines before that date that off-site incidents are not occurring at unacceptable frequencies or levels. Do not use or distribute this product after 11/09/2018, unless you visit www.xtendimaxapplicationrequirements.com and can verify that EPA has amended this expiration date.

This label supersedes any previously issued labeling for this product, including previously issued supplemental labeling.

For weed control in asparagus, conservation reserve programs, corn, cotton, fallow croplands, general farmstead (noncropland), sorghum, grass grown for seed, hay, proso millet, pasture, rangeland, small grains, sod farms and farmstead turf, soybean, sugarcane, cotton with XtendFlex[®] Technology, and Roundup Ready 2 Xtend[®] Soybean.

XtendiMax[®] With VaporGrip[®] Technology is approved by U.S. EPA for all uses specified on this label in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin.

Check the registration status of each product in each state before using.

READ THE ENTIRE LABEL FOR XTENDIMAX[®] WITH VAPORGRIP[®] TECHNOLOGY BEFORE PROCEEDING WITH THE USE DIRECTIONS CONTAINED IN THIS LABEL.

READ AND FOLLOW ALL APPLICABLE DIRECTIONS, RESTRICTIONS, AND PRECAUTIONS ON THE CONTAINER LABEL AND BOOKLET AND WWW.XTENDIMAXAPPLICATIONREQUIREMENTS.COM.

Read the "LIMIT OF WARRANTY AND LIABILITY" statement at the end of the label before buying or using. If terms are not acceptable, return at once unopened.

EPA Reg. No. 524-617

1.0 INGREDIENTS

ACTIVE INGREDIENT:	
Diglycolamine salt of dicamba (3,6-dichloro- <i>o</i> -anisic acid)*	42.8%
OTHER INGREDIENTS:	57.2%
TOTAL:	100.0%

*contains 29.0%, 3,6-dichloro-*o*-anisic acid (2.9 pounds acid equivalent per U.S. gallon or 350 grams per liter).

RESTRICTED USE PESTICIDE

For retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.

GROUP 4 HERBICIDE



RESTRICTED USE PESTICIDE

For Retail Sale To and Use Only by Certified Applicators or persons under their direct supervision, and only for those uses covered by Certified Applicators certification.

This label supersedes any previously issued labeling, including previously issued supplemental labeling.

This EPA registration expires December 20, 2018 unless the US EPA determines before that date that off-site incidents are not occurring at unacceptable frequencies or levels. **DO NOT** use or distribute this product after December 20, 2018, unless you visit www.EngeniaQuestions.com and can verify that the EPA has amended this expiration date.



We create chemistry

Group 4 Herbicide

Engenia[®] SPECIN

Herbicide

For weed control in Dicamba-tolerant (DT) cotton¹; Dicamba-tolerant (DT) soybean¹; asparagus; conservation reserve programs (CRP); corn; cotton; fallow cropland; farmstead turf (noncropland) and sod farms; grass grown for seed; pasture, hay, rangeland, and farmstead (noncropland); proso millet; small grain; sorghum; soybean; and sugarcane

¹Only for use in states listed as US EPA approved in the Dicamba-tolerant (DT) Crops section of this label.

Active Ingredient¹:

Dicamba: N,N-Bis-(3-aminopropyl)methylamine salt of 3,6-dichloro- <i>o</i> -anisic acid	60.8%
Other Ingredients:	39.2%
Total:	100.0%

¹Contains 48.38% dicamba (5 pounds acid equivalent per gallon or 600 grams per liter)

EPA Reg. No. 7969-345

EPA Est. No.

KEEP OUT OF REACH OF CHILDREN
CAUTION/PRECAUCION

Pesticide Application: Critical Aspects and Issues

Clarity[®] herbicide

For weed control in asparagus, conservation reserve programs, corn, cotton, fallow croplands, general farmstead (noncropland), sorghum, grass grown for seed, hay, proso millet, pasture, rangeland, small grains, sod farms and farmstead turf, soybean, and sugarcane.

Active Ingredient:

Diglycolamine salt of 3,6-dichloro-o-anisic acid* 58.1%

Other Ingredients: 41.9%

Total 100.0%

*Contains 39.4% 3,6-dichloro-o-anisic acid (4 pounds acid equivalent per gallon or 450 grams per liter).

EPA Reg No. 7969-137

EPA Est. No.

KEEP OUT OF REACH OF CHILDREN CAUTION/PRECAUCIÓN

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See inside booklet for complete First Aid, Precautionary Statements, Directions for Use, State-Specific Crop and/or Use Site Restrictions and Conditions of Sale and Warranty.

In case of an emergency endangering life or property involving this product, call day or night 1-800-832-HELP (4357).

Net Contents:

BASF Corporation
26 Davis Drive, Research Triangle Park, NC 27709



DuPont[™] FeXapan[™] herbicide Plus VaporGrip[®] Technology

GROUP 4 HERBICIDE

For weed control in conservation reserve programs, corn, cotton, fallow croplands, general farmstead (noncropland), sorghum, grass grown for seed, hay, proso millet, pasture, rangeland, small grains, soybean, sugarcane, cotton with XtendFlex Technology, and Roundup Ready 2 Xtend Soybean.

This label supersedes any previously issued labeling for this product, including previously issued supplemental labeling.

DuPont[™] FeXapan[™] herbicide Plus VaporGrip[®] Technology is approved by U.S. EPA for all uses specified on this label in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin.

Check the registration status of each product in each state before using.

Active Ingredient	By Weight
Diglycolamine salt of dicamba (3,6-dichloro-o-anisic acid)*	42.8%
Other Ingredients	57.2%
TOTAL	100.0%

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EPA Reg. No. 352-913

EPA Est. No.

Nonrefillable Container

Net:

Pesticide Application: Critical Aspects and Issues

Mandatory Dicamba Training

The federal registrations for the following products require that prior to applying these products, the applicator must complete dicamba or auxin-specific training:

- XtendiMax® herbicide with VaporGrip® Technology (Monsanto)
- FeXapan® herbicide plus VaporGrip® Technology (DuPont)
- Engenia® Herbicide (BASF)

Certain states require that an applicator complete training conducted by the state. Please check with your state pesticide regulatory agency for training and application requirements imposed by your state.

If you are applying these products in one of the following states, you must attend that state's mandatory training: [Alabama](#), [Georgia](#), [Indiana](#), [Missouri](#), [Mississippi](#), [North Carolina](#), [Tennessee](#)

If you plan to apply in a state that does not require the training be provided by the state, Monsanto is providing training events to meet this requirement.

FEXAPAN™ HERBICIDE PLUS VAPORGRIP® TECHNOLOGY

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Better Weed Management With Less Worry About Dicamba Volatility

DuPont™ FeXapan™ herbicide Plus VaporGrip® Technology gives soybean and cotton growers more ways to handle resistant weeds in a low-volatility dicamba formulation.



FeXapan™ Stewardship Overview
Dave Roome describes the benefits of following FeXapan™ stewardship best practices.

[VIEW MEDIA](#)

RESTRICTED USE PESTICIDE: For retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.

Take full advantage of dicamba-tolerant soybean and cotton varieties and realize effective weed control with FeXapan™ herbicide Plus VaporGrip® Technology.

Solutions Approach

As part of the Roundup Ready 2 Xtend® Acre Solution, FeXapan™ herbicide Plus VaporGrip® Technology uses a low-volatility dicamba formulation to add a needed mode of action to weed-control program while reducing potential for off-target herbicide movement from volatility. Always follow FeXapan™ herbicide Plus VaporGrip® Technology application best practices for best weed-control results

and to support long-term value of dicamba herbicides.



2018 Dicamba Applicator Training [▶](#)

Pesticide Application: Critical Aspects and Issues

Banvel® Herbicide

PEEL HERE
TO OPEN

FOR WEED CONTROL IN CORN, SORGHUM, SMALL GRAINS,
PASTURE, HAY, RANGELAND, FARMSTEAD (NON-CROPLAND), FALLOW,
SUGARCANE, ASPARAGUS, TURF AND GRASS SEED CROPS.

ACTIVE INGREDIENT	By Weight
Dimethylamine salt of dicamba (3,6-dichloro-o-anisic acid)*	49.4%
OTHER INGREDIENTS	50.6%
TOTAL	100.0%

* This product contains 41.0% 3,6-dichloro-o-anisic acid (dicamba) or 4 pounds per gallon (480 g/L).

KEEP OUT OF REACH OF CHILDREN CAUTION/PRECAUCIÓN

Si usted no entiende la etiqueta, 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.)

See inside of booklet for complete Precautionary Statements and Directions For Use.

Manufactured for:
ARYSTA LIFESCIENCE NORTH AMERICA, LLC
15401 Weston Parkway, Suite 150
Cary, North Carolina 27513

EPA Registration No. 66330-276
EPA Establishment No. 68323-TX-001

For Product Information: 1-866-761-9397

AD091109
2040549—081110

Clarity® herbicide

For weed control in asparagus, conservation reserve programs, corn, cotton, fallow croplands, general farmstead (noncropland), sorghum, grass grown for seed, hay, proso millet, pasture, rangeland, small grains, sod farms and farmstead turf, soybean, and sugarcane.

Active Ingredient:	
Diglycolamine salt of 3,6-dichloro-o-anisic acid*	58.1%
Other Ingredients:	41.9%
Total	100.0%

*Contains 39.4% 3,6-dichloro-o-anisic acid (4 pounds acid equivalent per gallon or 480 grams per liter).

EPA Reg No. 7969-137

EPA Est. No.

KEEP OUT OF REACH OF CHILDREN CAUTION/PRECAUCIÓN

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See inside booklet for complete **First Aid, Precautionary Statements, Directions For Use, State-Specific Crop and/or Use Site Restrictions and Conditions of Sale and Warranty.**

In case of an emergency endangering life or property involving this product, call day or night 1-800-832-HELP (4357).

Net Contents:

BASF Corporation
26 Davis Drive, Research Triangle Park, NC 27709

Does Water Quality Make A Difference in the Performance of A Pesticide?



Slides from: Dr. Cecil Tharp, Montana State University
Dr. Fred Whitford, Purdue
University of Nebraska Extension

Review (of pH and hardwater)

- **pH:**

- pH is the measure of hydrogen ions (H^+) and hydroxide ions (OH^-)
- Acid solutions are <7
- Alkaline solutions are >7
- **Weak acid herbicides breakdown within high pH solutions (>7)**
- **Sulfonylurea herbicides are insoluble in a low pH solution (<7)**

- **Hardwater:**

- **Can reduce the effectiveness of weak acid pesticides**, especially if the pH of the water is above the ideal range.
- **Ions attach to water molecules and the pesticide**
 - Can't be absorbed by the target pest, or
 - Is absorbed at a slower rate, or
 - Forms insoluble salts

Review (turbidity of water)

- **Turbidity is the total suspended solids (TSS) in water.**
- **Suspended solids refers to suspended solids, soil, and/or organic matter**
- **Many pesticides bind to soil particulates (high soil sorption potential; KOC)**
- **Pesticides such as glyphosate, diquat, paraquat, bifenthrin and permethrin bind readily in turbid water.**
- **If water is murky then use an alternative water source; or use only select pesticides with low KOC's and install additional inline filters.**

Pesticide Application: Critical Aspects and Issues



Complete Directions for Use

EPA Reg. No. 524-475

AVOID CONTACT OF HERBICIDE WITH FOLIAGE, STEMS, EXPOSED NON-WOODY ROOTS OR FRUIT OF CROPS (EXCEPT AS SPECIFIED FOR INDIVIDUAL ROUNDUP READY® CROPS). DESIRABLE PLANTS AND TREES, BECAUSE SEVERE INJURY OR DESTRUCTION MAY RESULT.

Herbicide for Roundup Ready Crops.

Selective broad-spectrum weed control in Roundup Ready crops.

Non-selective, broad-spectrum weed control for many cropping systems, farmsteads and Conservation Reserve Program acres.

2010-1

Not all products listed on this label are registered for use in California. Check the registration status of each product in California before using.

Read the entire label before using this product.

Use only according to label instructions.

Read the "LIMIT OF WARRANTY AND LIABILITY" statement at the end of the label before buying or using. If terms are not acceptable, return at once unopened.

THIS IS AN END-USE PRODUCT. MONSANTO DOES NOT INTEND AND HAS NOT REGISTERED IT FOR REFORMULATION. SEE INDIVIDUAL CONTAINER LABEL FOR REPACKAGING LIMITATIONS.

1.0 INGREDIENTS

ACTIVE INGREDIENT:

*Glyphosate, N-(phosphonomethyl)glycine, in the form of its isopropylamine salt	41.0%
OTHER INGREDIENTS	59.0%
	100.0%

*Contains 480 grams per liter or 4 pounds per U.S. gallon of the active ingredient glyphosate, in the form of its isopropylamine salt. Equivalent to 356 grams per liter or 3 pounds per U.S. gallon of the acid, glyphosate.

7.2 Tank Mixing Procedure

Mix labeled tank mixtures of this product with water as follows:

1. Place a 20- to 35-mesh screen or wetting basket over filling port.
2. Through the screen, fill the spray tank one-half full with water and start agitation.
3. If ammonium sulfate is used add it slowly through the screen into the tank. Continue agitation. Ensure that dry ammonium sulfate is completely dissolved in the spray tank before adding other products.
4. If a wettable powder is used, make a slurry with the water carrier, and add it SLOWLY through the screen into the tank. Continue agitation.
5. If a flowable formulation is used, premix one part flowable with one part water. Add diluted mixture SLOWLY through the screen into the tank. Continue agitation.
6. If an emulsifiable concentrate formulation is used, premix one part emulsifiable concentrate with two parts water. Add diluted mixture slowly through the screen into the tank. Continue agitation.
7. Continue filling the spray tank with water and add the required amount of this product near the end of the filling process.
8. Add individual formulations to the spray tank as follows: wettable powder, flowable, emulsifiable concentrate, drift control additive and water soluble liquid.

Maintain good agitation at all times until the contents of the tank are sprayed. If the spray mixture is allowed to settle, thorough agitation is required to resuspend the mixture before spraying is resumed.

Keep by-pass line on or near the bottom of the tank to minimize foaming. Screen size in nozzle or line strainers no finer than 50-mesh are necessary.

7.4 Ammonium Sulfate

The addition of 1 to 2 percent dry ammonium sulfate by weight or 8.5 to 17 pounds per 100 gallons of water may increase the performance of this product, particularly under hard water conditions, drought conditions or when tank mixed with certain residual herbicides, on annual and perennial weeds. The equivalent rate of ammonium sulfate in a liquid formulation may also be used. Ensure that dry ammonium sulfate is completely dissolved in the spray tank before adding herbicides. Thoroughly rinse the spray system with clean water after use to reduce corrosion.

NOTE: When using ammonium sulfate, apply this product at rates specified in this label. Lower rates will result in reduced performance.

11.5 Rangelands

TYPES OF APPLICATIONS: Postemergence.

USE INSTRUCTIONS: This product will control or suppress many annual weeds growing in perennial cool and warm-season grass rangelands.

Preventing viable seed production is key to the successful control and invasion of annual grassy weeds in rangelands. Follow-up applications in sequential years should eliminate most of the viable seeds.

Delay grazing of treated areas to encourage growth of desirable perennials. Allowing desirable perennials to flower and reseed in the treated area will encourage successful transition.

PRECAUTIONS, RESTRICTIONS: Do not use ammonium sulfate when spraying rangeland grasses with this product. Do not apply more than 3 quarts per acre per year.

Pesticide Application: Critical Aspects and Issues



BRIMSTONE®

Buffer / Water Conditioner / Activator

FOR USE WITH HERBICIDES REGISTERED FOR AGRICULTURAL, INDUSTRIAL, RIGHTS-OF-WAY, NON-CROPLAND AND OTHER USES

PRINCIPAL FUNCTIONING AGENTS	% BY WT.
Monocarbamide dihydrogen sulfate, alkoxy/ated amine ethoxylate, propane-1,2,3-triol, alkyl glycol polyoxyethylene.....	80.00%
CONSTITUENTS INEFFECTIVE AS SPRAY ADJUVANT.....	20.00%
TOTAL.....	100.00%

Surfactant content.....28%

CA Reg. No 2935-50193

WA Reg. No. 2935-10002

KEEP OUT OF REACH OF CHILDREN



DANGER

May be corrosive to metals. Harmful if swallowed. Causes severe skin burns and serious eye damage. May cause respiratory irritation.

BRIMSTONE can improve both pesticide spray application and pesticide efficacy. BRIMSTONE can eliminate the antagonistic effects of hard water on herbicide efficacy. BRIMSTONE is designed primarily to be applied with herbicides which utilize glyphosate as the active ingredient. BRIMSTONE will adjust solutions to a low pH and tie up metal ions which can deactivate glyphosate and other sensitive pesticides. However, it is suitable and effective for most pesticides and nutritional products which can be used with wetter/spreader type adjuvants. Optimum application coverage and results can be influenced by many factors. Therefore, it is recommended that the applicator carefully observe the spray deposit and adjust the adjuvant rate accordingly to ensure thorough coverage with minimal plant runoff.

Pesticide Application: Critical Aspects and Issues



Breeze®

**NONIONIC SURFACTANT, SPREADER, PENETRANT, WATER CONDITIONING
AGENT AND ACIDIFIER**

Protected by U.S. Patent No. 5,945,377

With

CornSorb® Technology

PRINCIPAL FUNCTIONING AGENTS:

Saccharides, alkyl polyglucoside, ammonium sulfate..... 65%

CONSTITUENTS INEFFECTIVE AS SPRAY ADJUVANTS..... 35%

TOTAL..... 100%

Surfactant content 20% (Note, the higher use rates of 0.5 - 0.75 % v/v compensates for the low surfactant %)

All ingredients are exempt from the requirements of a tolerance in 40 CFR 180.

KEEP OUT OF REACH OF CHILDREN



WARNING/AVISO

Si usted no entiende la etiqueta, 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.)

Causes eye irritation. Flammable liquid and vapor. May cause an allergic skin reaction.

GENERAL INFORMATION

Breeze® is a multicomponent adjuvant system designed to enhance the efficacy of many pesticides applied by ground or air on turfgrass, ornamentals, trees, exterior pests, aquatics, and other non-crop areas.

As a water conditioner, Breeze® will tie-up with free ions in spray tank solutions that can inhibit many pesticide's performance. Breeze® also acts as an acidifying buffering agent that will lower the pH of the spray solution preventing hydrolysis of many pesticides, especially fungicides and insecticides. While protecting the spray solution, Breeze® also works as a nonionic surfactant, promoting spreading for improved plant coverage and penetration to move more active ingredient into the plant.

What is the take home message?





21 horseweed populations
3 weeks after glyphosate at 2X the labeled rate



Herbicide Tolerance

Herbicide tolerance is the **inherent ability of a species to survive** and reproduce after herbicide treatment. This implies that there was no selection or genetic manipulation to make the plant tolerant; it is naturally tolerant.

Selective herbicides are effective because the crop is tolerant to the herbicide.

Some herbicides are effective only on some weeds.

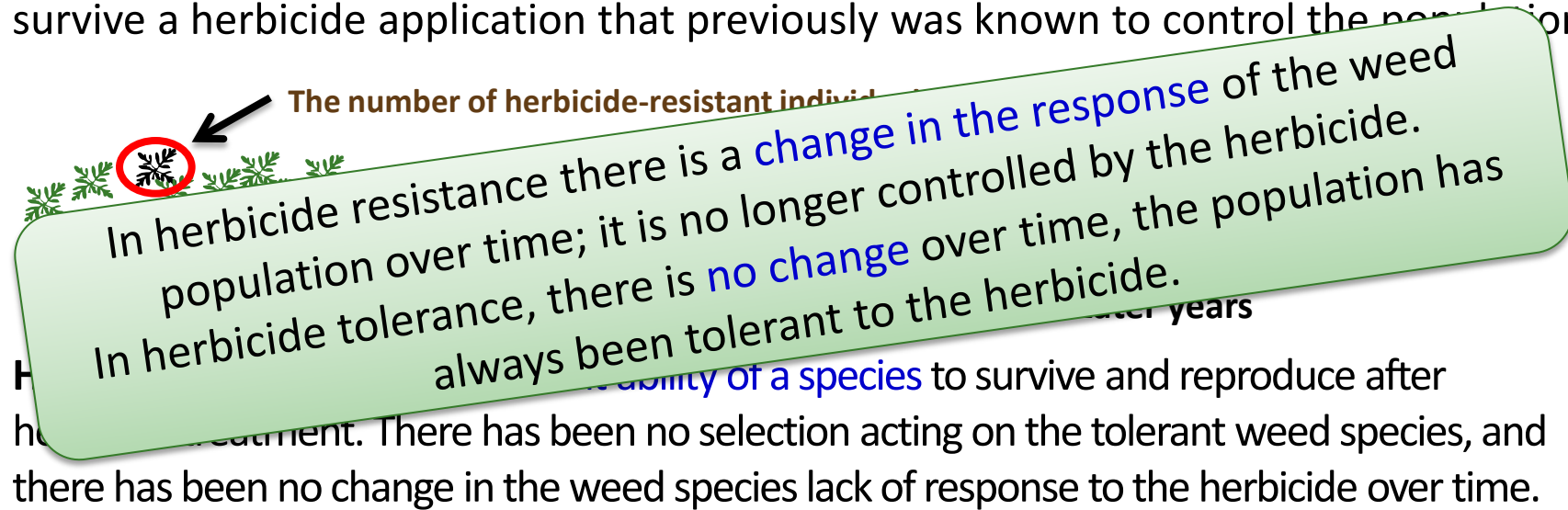
Herbicide tolerance is not synonymous with herbicide resistance.

- By definition, if a weed has never been controlled and there has been no change in the weed population's lack of response to a herbicide over time, the population is tolerant.



Herbicide Resistance Defined

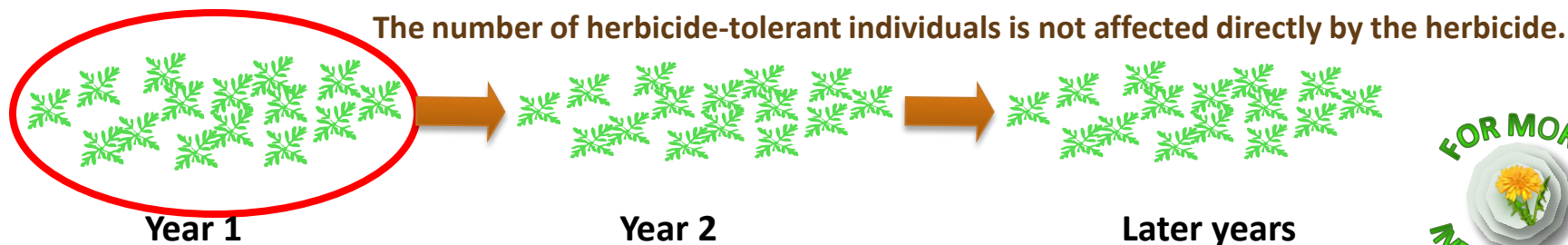
Herbicide resistance can be defined as the **acquired ability of a weed population** to survive a herbicide application that previously was known to control the population.

**The number of herbicide-resistant individuals**

In herbicide resistance there is a **change in the response** of the weed population over time; it is no longer controlled by the herbicide.

In herbicide tolerance, there is **no change** over time, the population has always been tolerant to the herbicide.

Ability of a species to survive and reproduce after herbicide treatment. There has been no selection acting on the tolerant weed species, and there has been no change in the weed species lack of response to the herbicide over time.



Herbicide Resistance: Basic Principles

Herbicide resistance is the result of naturally occurring processes.

Herbicide-resistant individuals or **biotypes*** are present naturally within the weed population at very low frequencies. These individuals have a herbicide resistance mechanism that allows them to survive the application of a herbicide.

Weed control failures do not automatically mean that the weeds are herbicide-resistant.

* Biotypes are plants within a species that have biological characteristics that are not common to the population as a whole.

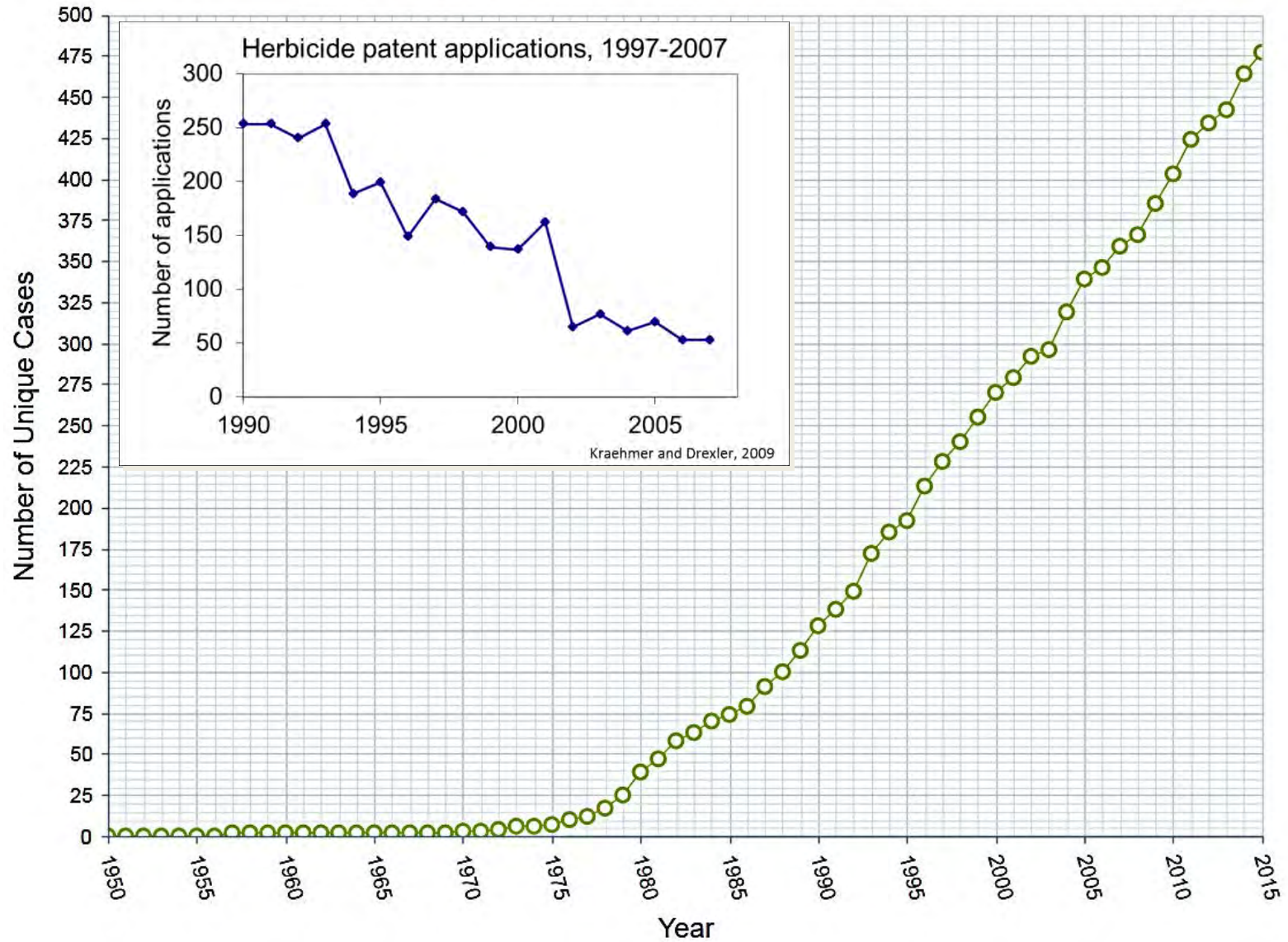


Resistance is **heritable**. It can be passed from one generation to the next.



- A total of 480 confirmed herbicide-resistant weed biotypes have been documented to date (147 dicots and 105 monocots).
- There is now resistance to 23 of the 26 herbicide Sites of Action.

Chronological Increase in Resistant Weeds Globally



Herbicide Resistance Types

Single Herbicide Resistance

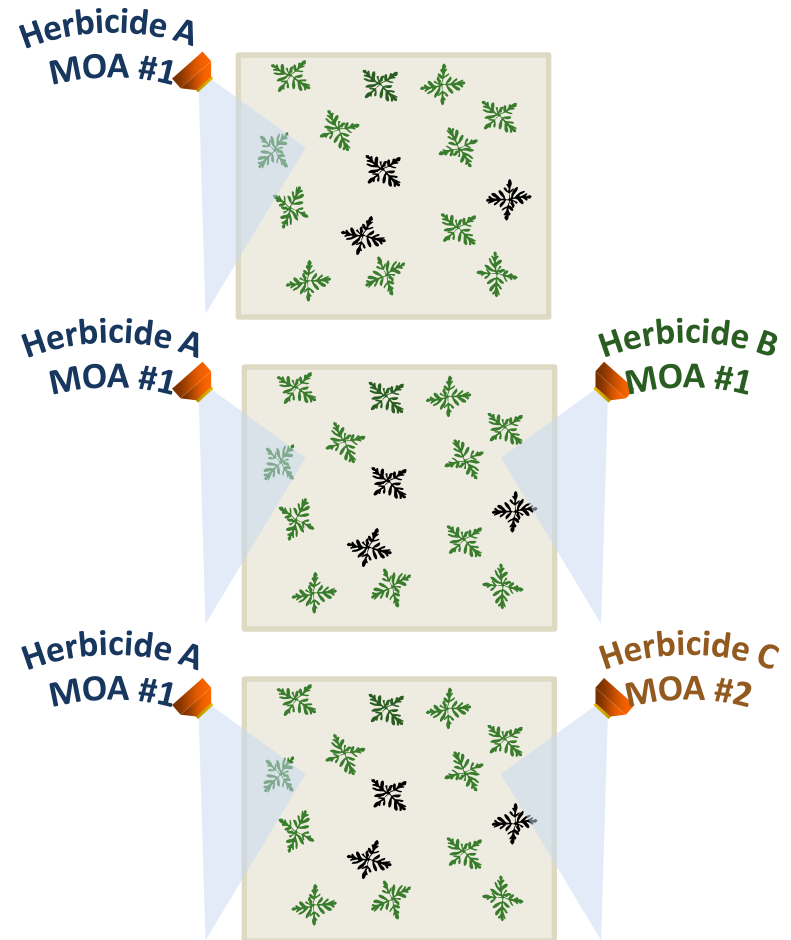
- Resistant to only one herbicide

Cross Herbicide Resistance

- Resistant to two or more herbicide families with same mechanism of action
- Single resistance mechanism

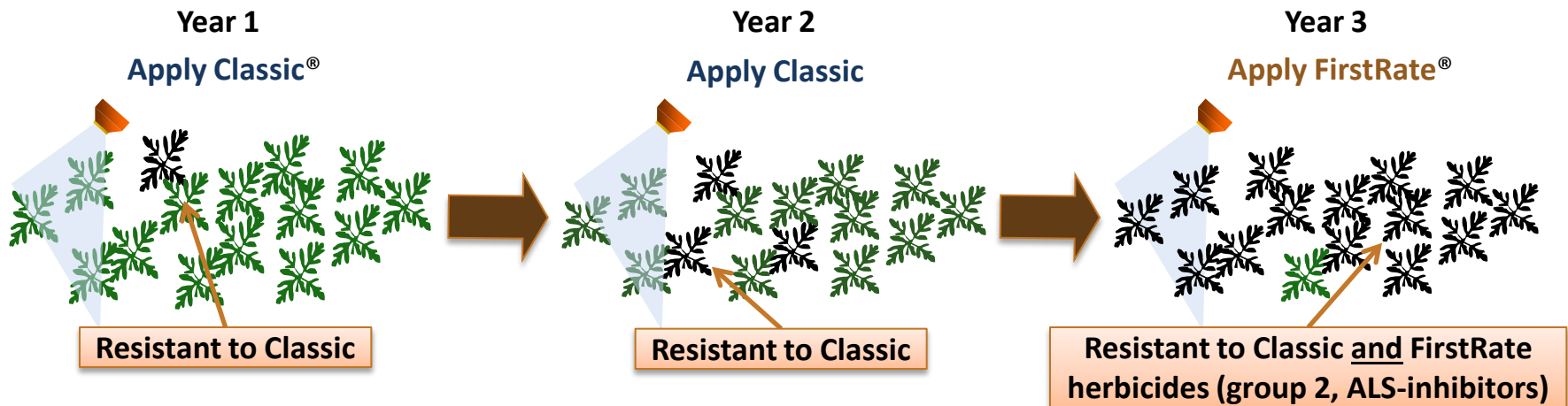
Multiple Herbicide Resistance

- Resistant to two or more herbicides with different mechanisms of action
- May be the result of two or more different resistance mechanisms



Herbicide Resistance Types: Cross Resistance

An example with common ragweed



Classic, a sulfonylurea, and FirstRate, a triazolopyrimidine, both belong to the ALS-inhibitors, or group 2 herbicides. Both herbicide products have the same mechanism of action.

CAUTION: Weeds that are herbicide-resistant to one member of a herbicide mechanism of action group may or may not be cross-resistant to all herbicides within that group. Consult your local extension specialist for more information.

Herbicide Resistance Types

Single Herbicide Resistance

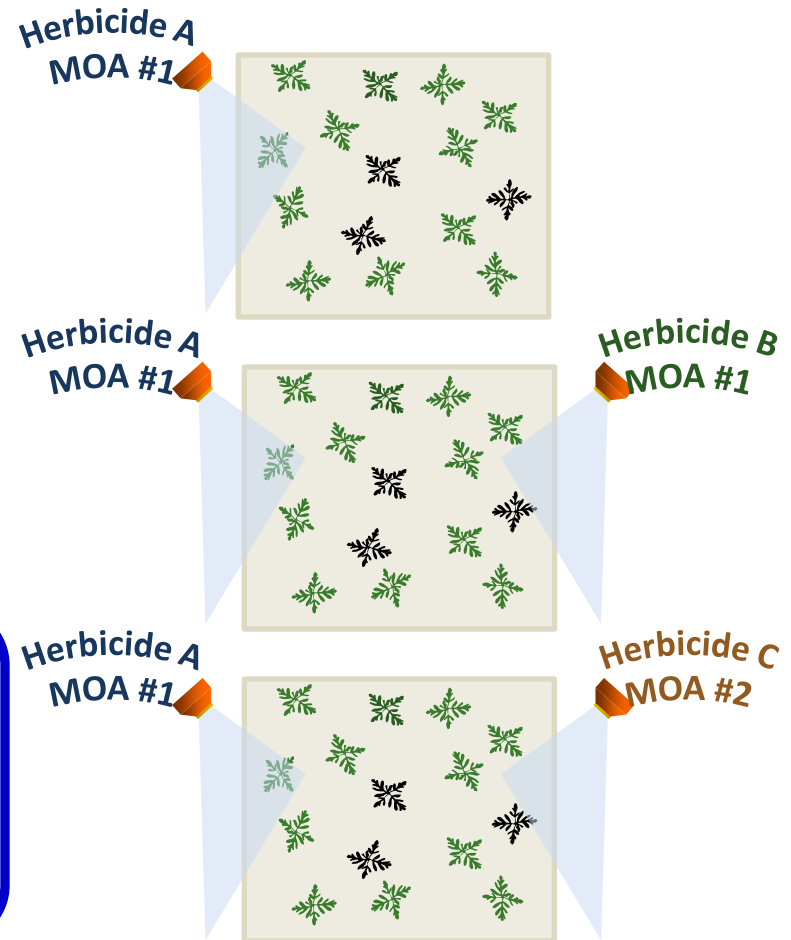
- Resistant to only one herbicide

Cross Herbicide Resistance

- Resistant to two or more herbicide families with same mechanism of action
- Single resistance mechanism

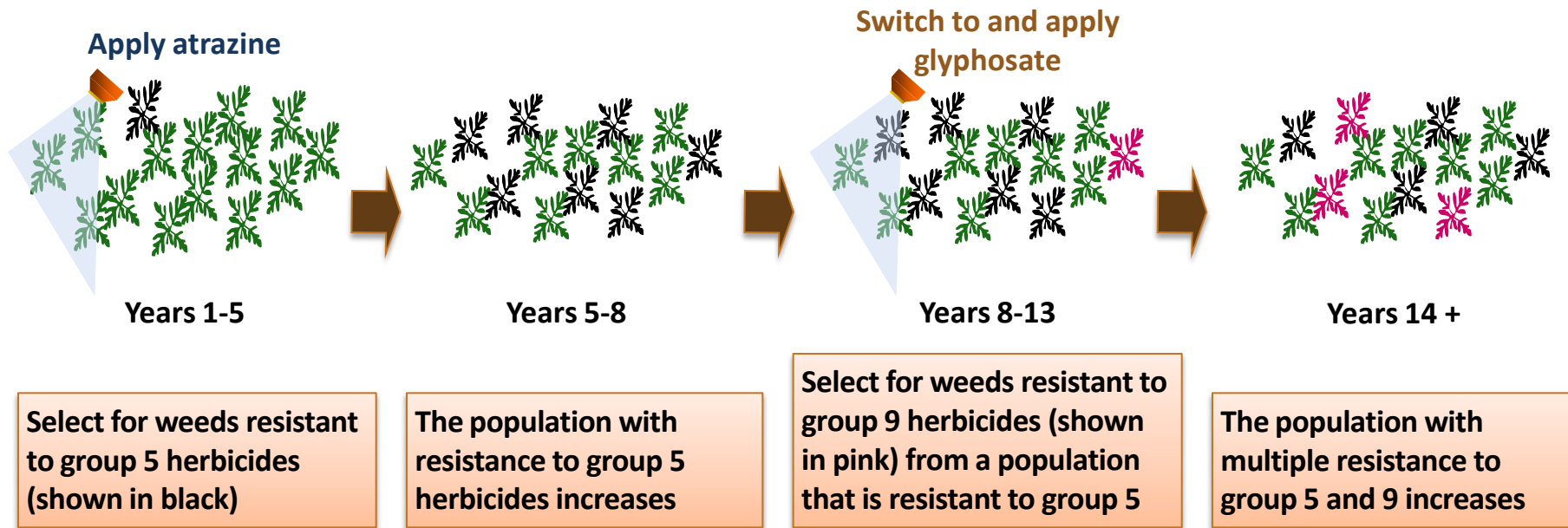
Multiple Herbicide Resistance

- Resistant to two or more herbicides with different mechanisms of action
- May be the result of two or more different resistance mechanisms



Herbicide Resistance Types: Multiple Resistance

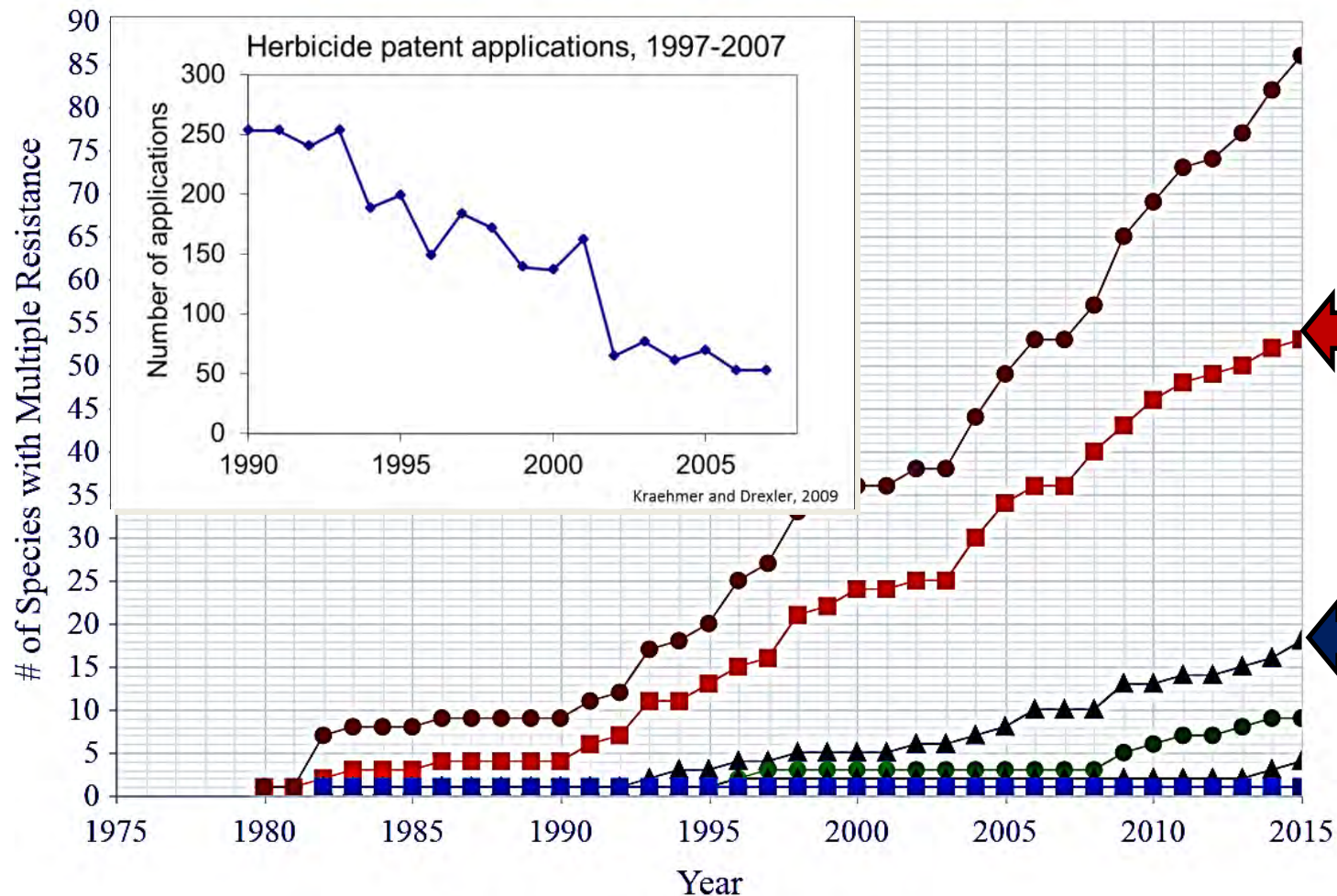
Example



Multiple resistance can occur following repeated applications of a single herbicide and selection for herbicide-resistant biotypes followed by repeated applications of another herbicide and selection for herbicide-resistant biotypes.

Weed Populations Resistant to Multiple Sites of Action

■ Two ■ Three ■ Four ■ Five ■ Six ■ Seven ■ Cumulative

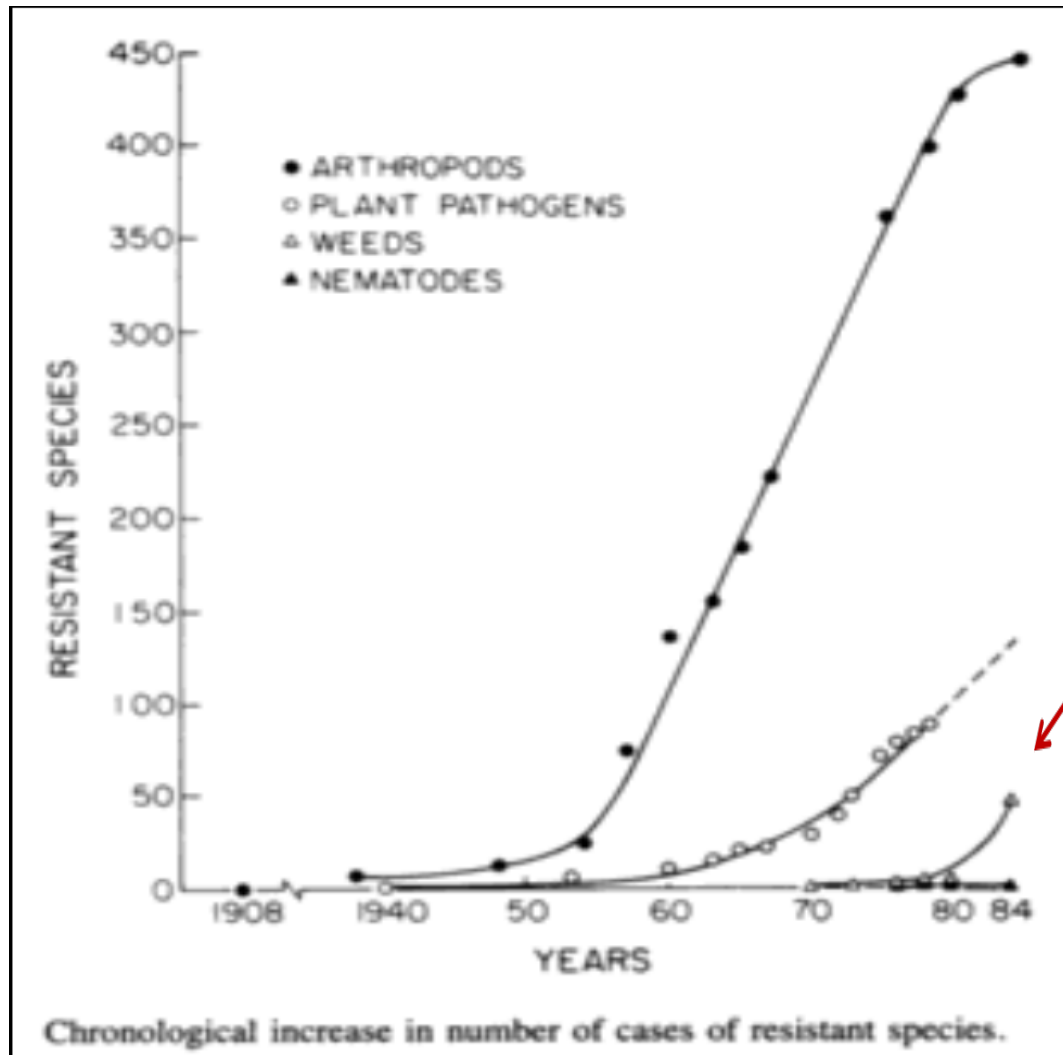


Herbicide Resistance



- **Kochia** (*Kochia scoparia*)
- 1984 in corn to Group 5 (atrazine)
- 1996 to Group 2 (ALS inhibitors) in wheat (Glean, Ally)
- 2007 to Group 9 (glycines) in KS (glyphosate) 2010 in CO

Herbicide Resistance



Herbicides got a late start, why?

Herbicide Resistance



DuPont™
Oust® XP

herbicide

Dispersible Granules

<i>Active Ingredient</i>	<i>By Weight</i>
--------------------------	------------------

Sulfometuron methyl {Methyl 2-[[[(4,6-dimethyl-2- pyrimidinyl)amino]-carbonyl]amino] sulfonyl]benzoate}	75%
--	-----

<i>Inert Ingredients</i>	<i>25%</i>
--------------------------	------------

TOTAL	100%
-------	------

EPA Reg. No. 352-601

- Thinking back 35+ years ago – 1980 – what herbicides were we using to manage vegetation – in general?
 - Roundup?
 - Telar, Escort, Oust?
 - Imazapyr?
 - 2,4-D, Banvel, Tordon?
 - Karmex, Bromacil, Pramitol?

Herbicide Resistance



DuPont™
Oust® XP

herbicide

Dispersible Granules

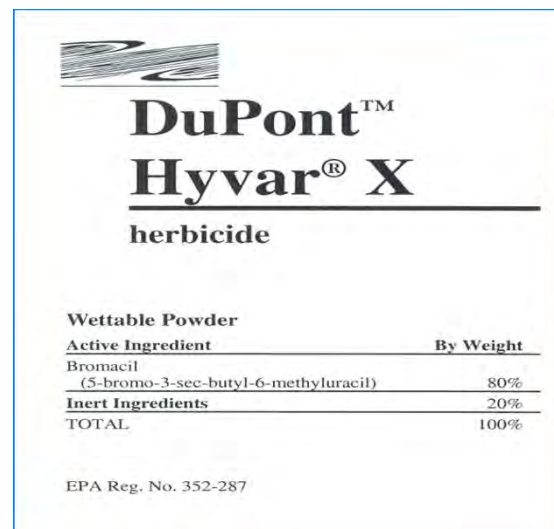
<i>Active Ingredient</i>	<i>By Weight</i>
Sulfometuron methyl {Methyl 2-[[[(4,6-dimethyl-2-pyrimidinyl)amino]-carbonyl]amino]sulfonyl}benzoate}	75%
<i>Inert Ingredients</i>	25%
TOTAL	100%

EPA Reg. No. 352-601

- Thinking back 35+ years ago – 1980 – what herbicides were we using to manage vegetation – in general?
 - What are the differences between the herbicides we used 30 years ago and the ones we are using today?

Herbicide Resistance

- How does it occur?



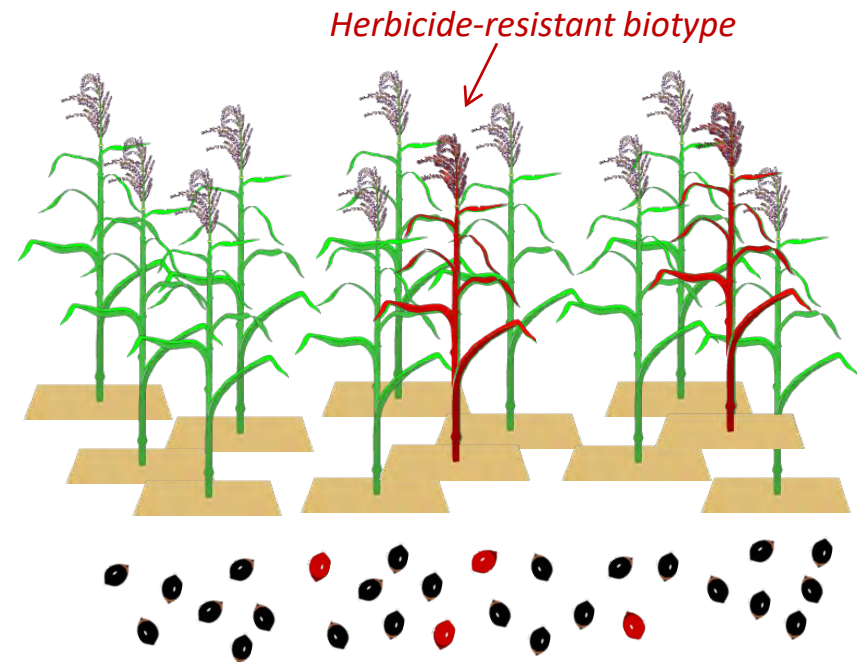
Progression of Weed Resistance

Weed resistance progresses logarithmically

Year 0

Credit: Mike DeFelice

Treatment	% Resistant Weeds in Population	Weed Control
0 Application	.0001	Excellent
1 st Application	.00143	Excellent



After first application, the herbicide kills individual weeds that are not resistant. The resistant weeds survive and produce seed.

Progression of Weed Resistance

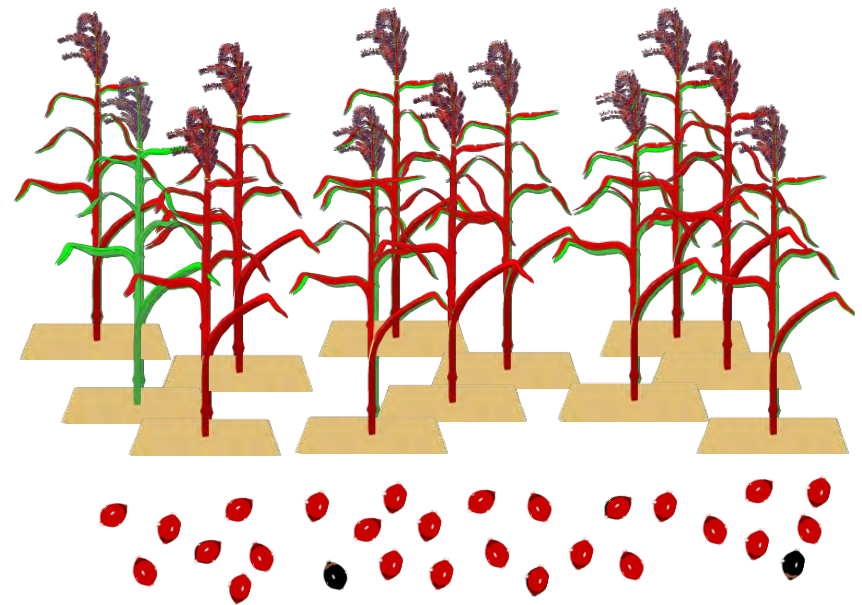
Weed resistance progresses logarithmically

Year 3

Credit: Mike DeFelice

Treatment	% Resistant Weeds in Population	Weed Control
0 Application	.0001	Excellent
1 st Application	.00143	Excellent
2 nd Application	.0205	Excellent
3 rd Application	.294	Excellent
4 th Application	4.22	Excellent

Herbicide resistance cannot be reversed in a practical time frame. In many cases, the seed pool is unlikely to change back because there is no fitness penalty.

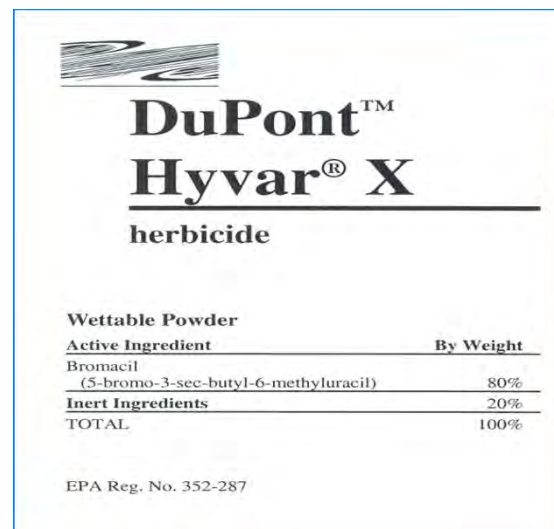


seed pool or seed bank in soil

Control may still be possible if the seed pool is almost completely composed of the susceptible type

Herbicide Resistance

- How does it occur?
- What are the factors that are involved in the process?
 - Characteristics of the herbicide
 - Characteristics of the weed species
 - Management practices



Herbicide Resistance - Herbicide

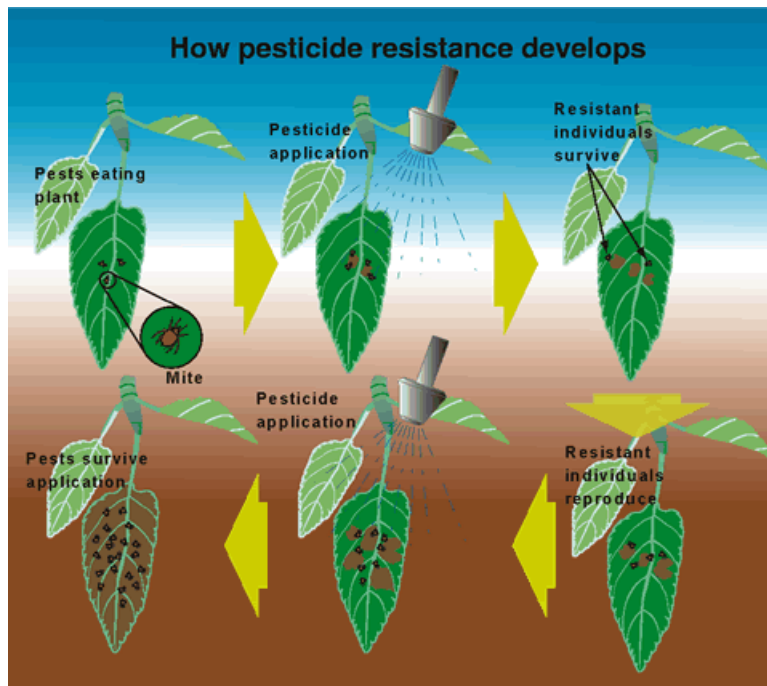
- Single site of action
 - High risk modes of action (ALS, ACCase, etc)
- Continuous exposure
 - The single most important cause of weed resistance is a management system in which repeated use of a single herbicide, or use of several herbicides with the same site of action, provides continuing selection pressure for herbicide resistance.

Herbicide Resistance - Plant

- More common
- Spreads faster


- **Target site resistance**: modification to the binding site on the herbicide target protein
 - Involves alteration of the target-site gene (*change in one gene*)
- **Non-target site resistance**: alteration endowing at least one of the following:
 - Reduced herbicide uptake/translocation
 - Increased rate of herbicide detoxification
 - Herbicide sequestration
 - Usually involves changes to many genes
 - Can confer resistance to several herbicides with different sites of action

Herbicide Resistance – Management






Herbicide resistance appears as a response to ***repeated use*** of a herbicide or to a different herbicide with a common **mode of action**




“MOA” is the key

Herbicidal Action	Representative A.I.	How it Looks
Plant Growth Regulation	2,4-D, Dicamba, Picloram, Clopyralid, Triclopyr, Aminopyralid, Aminocyclopyrachlor	




Herbicide Mechanism of Activity in the Plant

Herbicidal Action	Representative A.I.	How it Looks
Plant Growth Regulation	2,4-D, Dicamba, Picloram, Clopyralid, Triclopyr, Aminopyralid, Aminocyclopyrachlor	 
Amino Acid Synthesis Inhibition	Imazapyr, Glyphosate, Sulfometuron methyl, Metsulfuron methyl, Imazapic	

Herbicide Mechanism of Activity in the Plant

Herbicidal Action	Representative A.I.	How it Looks
Plant Growth Regulation	2,4-D, Dicamba, Picloram, Clopyralid, Triclopyr, Aminopyralid, Aminocyclopyrachlor	  
Amino Acid Synthesis Inhibition	Imazapyr, Glyphosate, Sulfometuron methyl, Metsulfuron methyl, Imazapic	
Photosynthesis Inhibition	Diuron, Bromacil, Hexazinone	

Herbicide Mechanism of Activity in the Plant

Herbicidal Action	Representative A.I.	How it Looks
Cell Membrane Disruptors	Paraquat, Diquat	
Plant Growth Inhibitors	Pendimethalin, Trifluralin	Inhibits the roots from growing.
Photosynthetic Pigment Inhibition	Norflurazon	
Lipid Biosynthesis Inhibition	Sethoxydim, Clethodim, Fluazifop-P-butyl,	

Herbicide Mechanism of Activity in the Plant

Herbicide Mechanism of Action - Summary

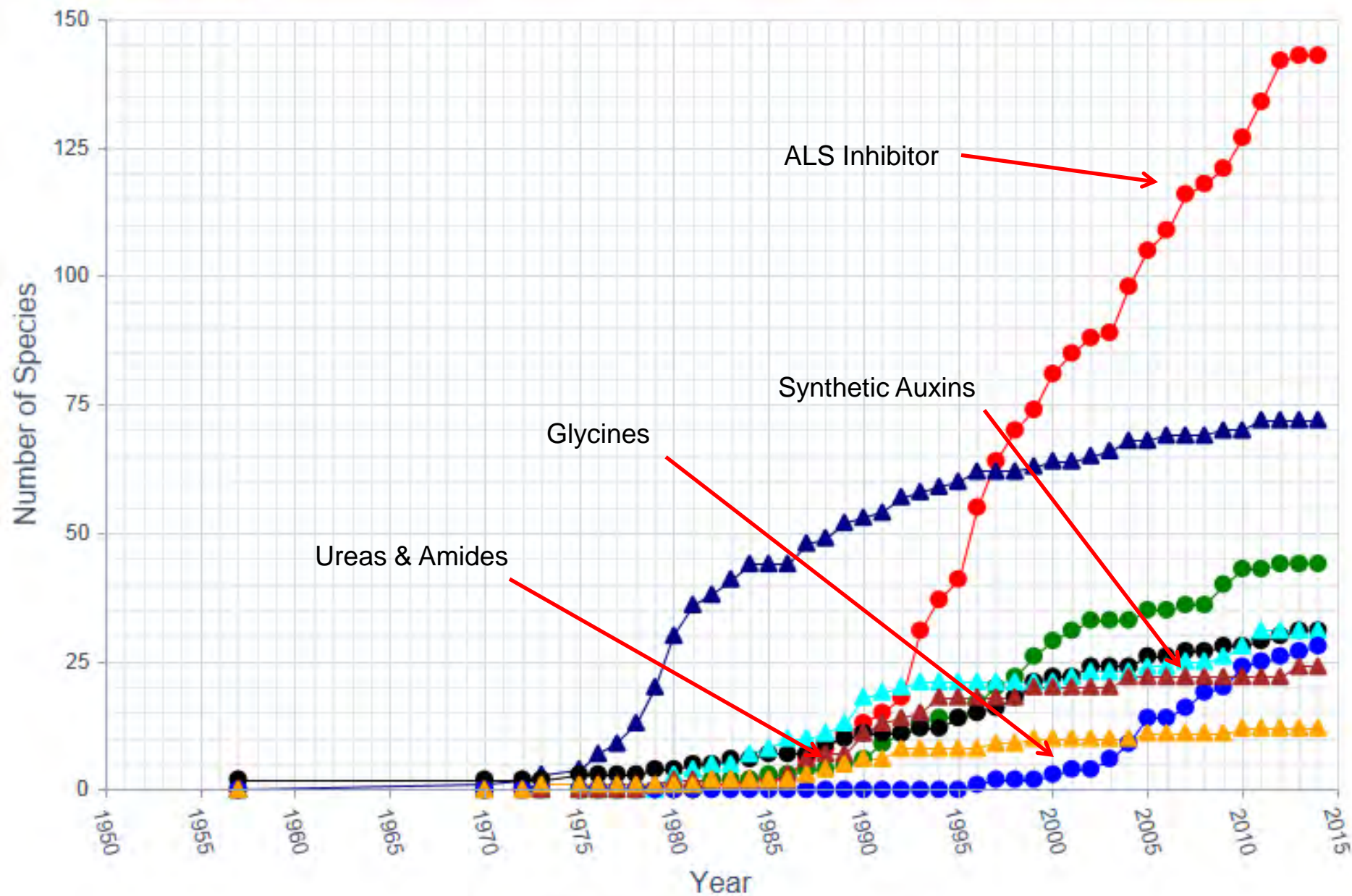
- **Aminopyralid**
- **Bromacil**
- **Clopyralid**
- **2,4-D**
- **Dicamba**
- **Diuron**
- **Glyphosate**
- **Imazapic**
- **Imazapyr**
- **Metsulfuron Methyl**
- **Rimsulfuron**
- **Sulfometuron methyl**
- **Tebuthiuron**
- **Triclopyr**



Herbicide Mechanism of Action - Summary

- **Aminopyralid**
- **Bromacil**
- **Clopyralid**
- **2,4-D**
- **Dicamba**
- **Diuron**
- **Glyphosate**
- **Imazapic**
- **Imazapyr**
- **Metsulfuron Methyl**
- **Rimsulfuron**
- **Sulfometuron methyl**
- **Tebuthiuron**
- **Triclopyr**
- **Plant Growth Regulator – Synthetic Auxin**
- **Amino Acid Biosynthesis Inhibitor – ALS Inhibitor**
- **Amino Acid Biosynthesis Inhibitor – EPSP Synthase Inhibitor**
- **Photosynthesis Inhibitor**

■ ALS Inhibitors
 ■ Triazines
 ■ ACCase Inhibitors
 ■ Synthetic Auxins
 ■ Bipyridiliums
 ■ Glycines
 ■ Ureas, Amides
 ■ Dinitroanilines



Number Resistant Species for Several Herbicide Sites of Action (WSSA Codes)

ACCase Inhibitors (1)

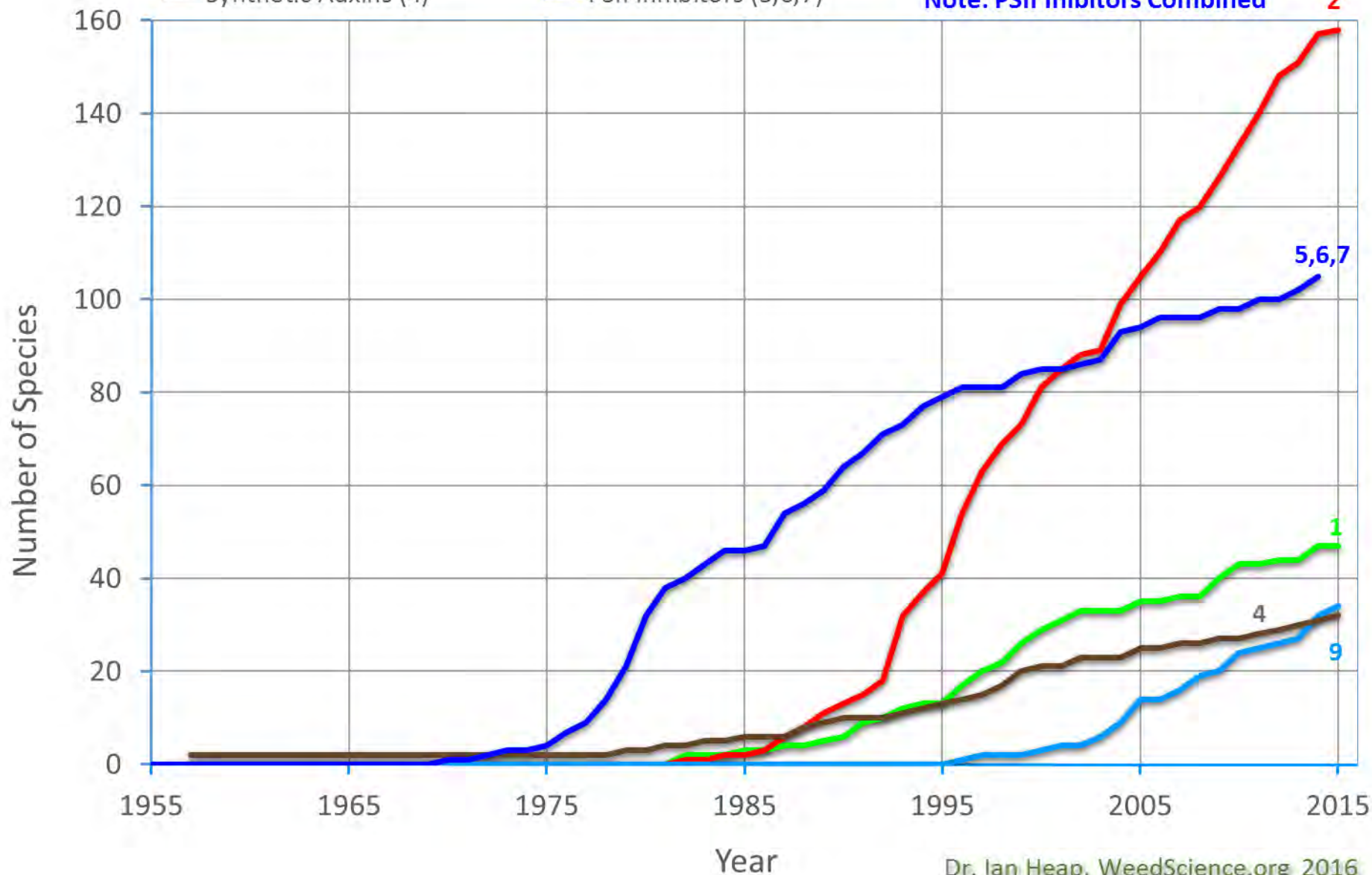
ALS Inhibitors (2)

EPSP Synthase Inhibitors (9)

Synthetic Auxins (4)

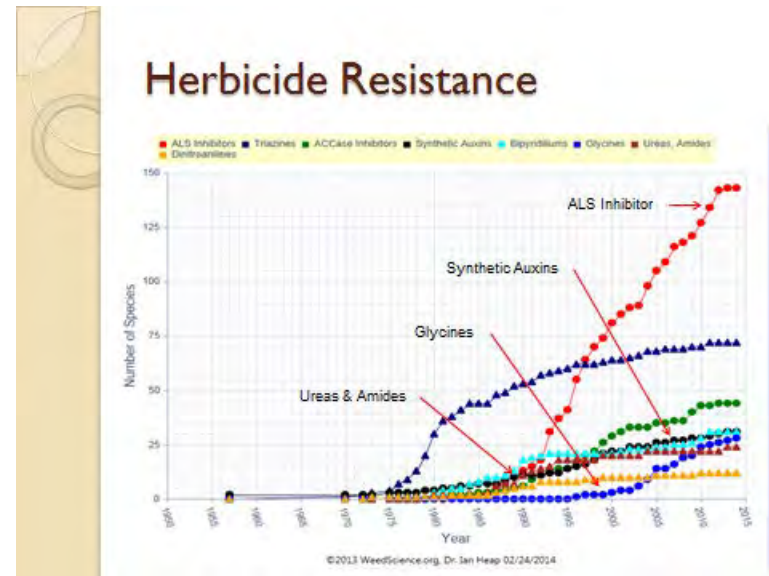
PSII Inhibitors (5,6,7)

Note: PSII Inhibitors Combined



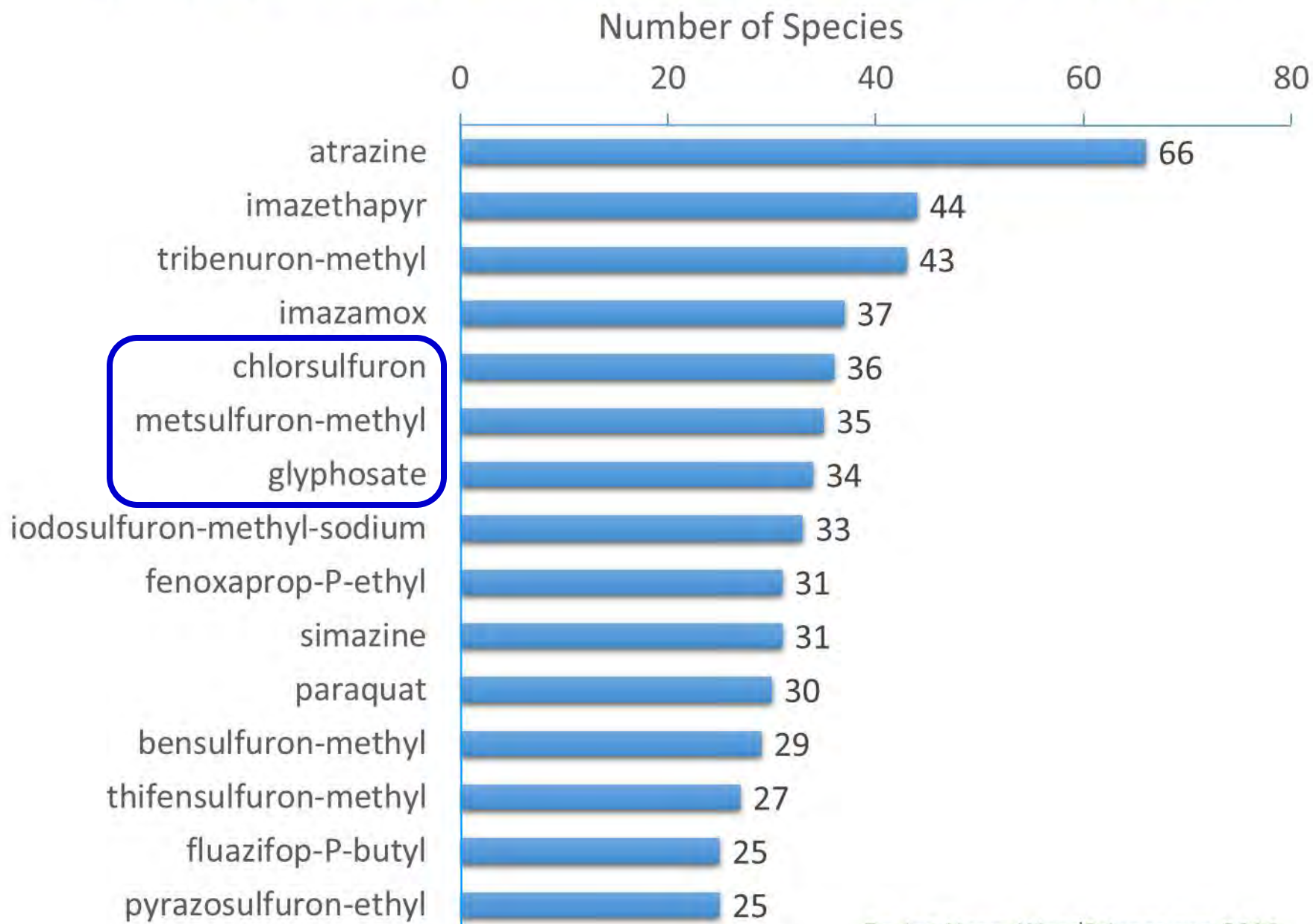
Herbicide Resistance

- In looking at the previous chart, which herbicide families are exhibiting significant resistance in plants being treated?
 - ALS Inhibiting Herbicides
 - Synthetic Auxin Herbicides
 - Glycine
 - Amides and Urea Herbicides

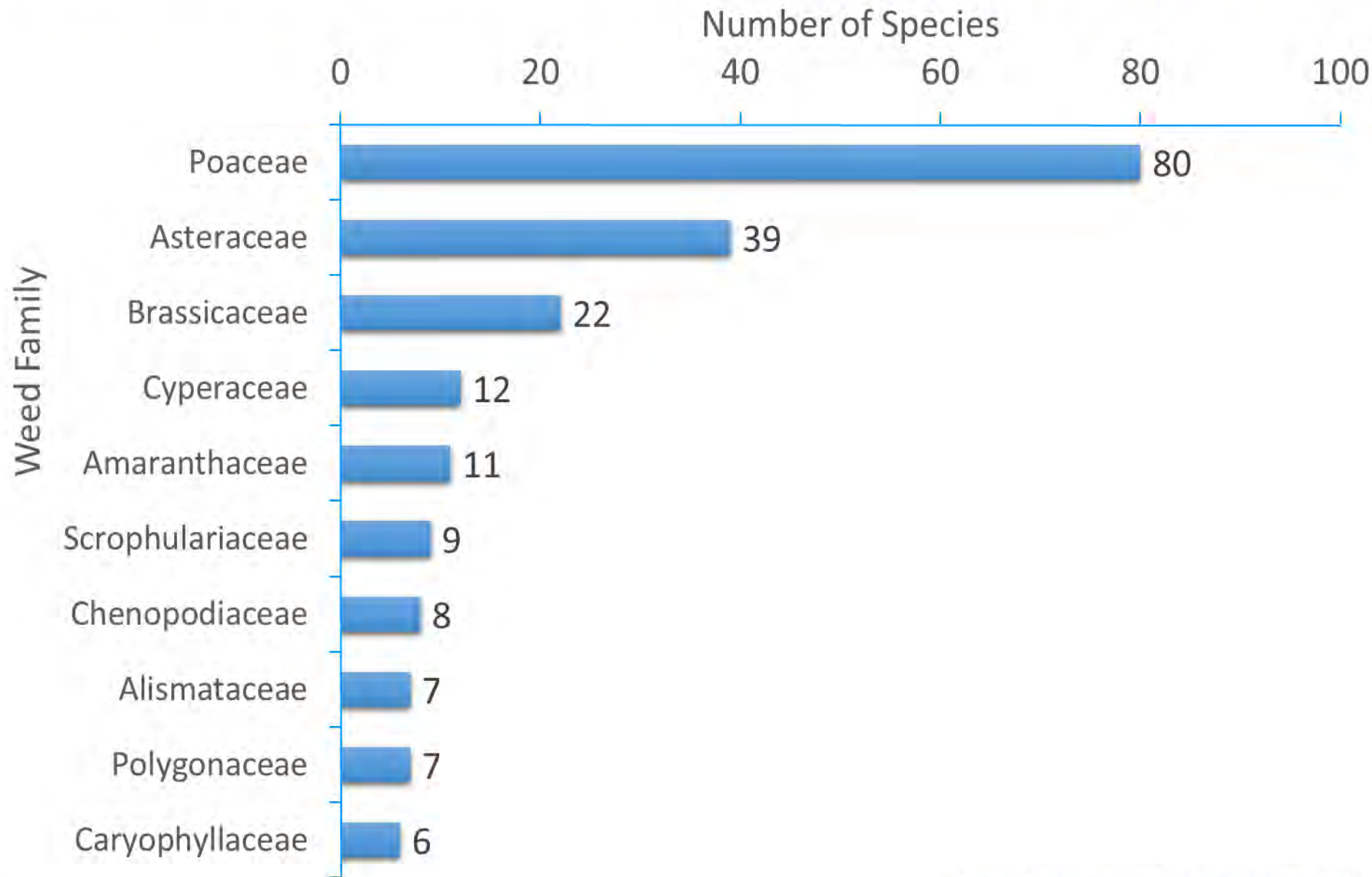


Number of Resistant Species to Individual Active Herbicides (Top 15)

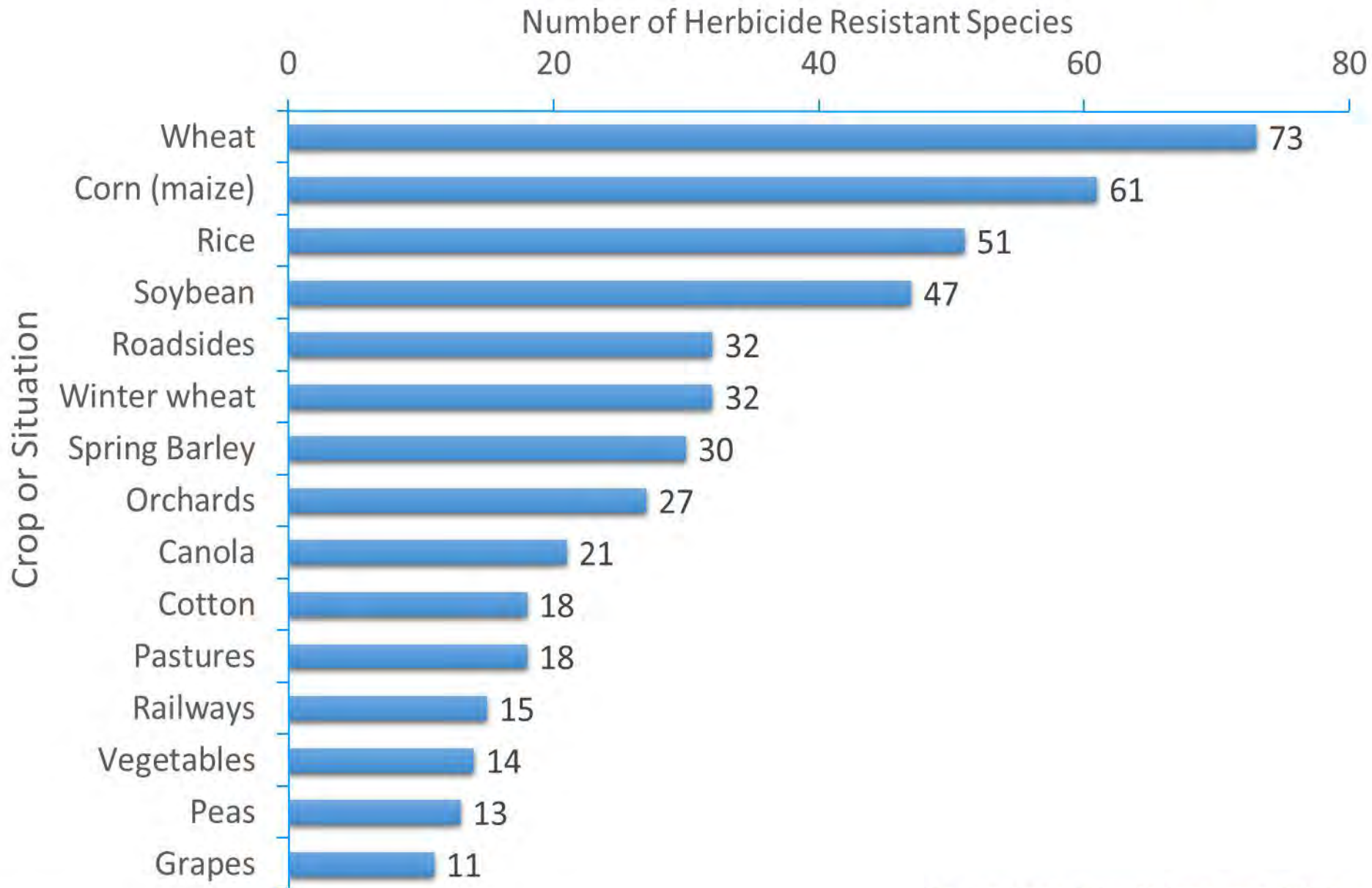
Herbicide Actives



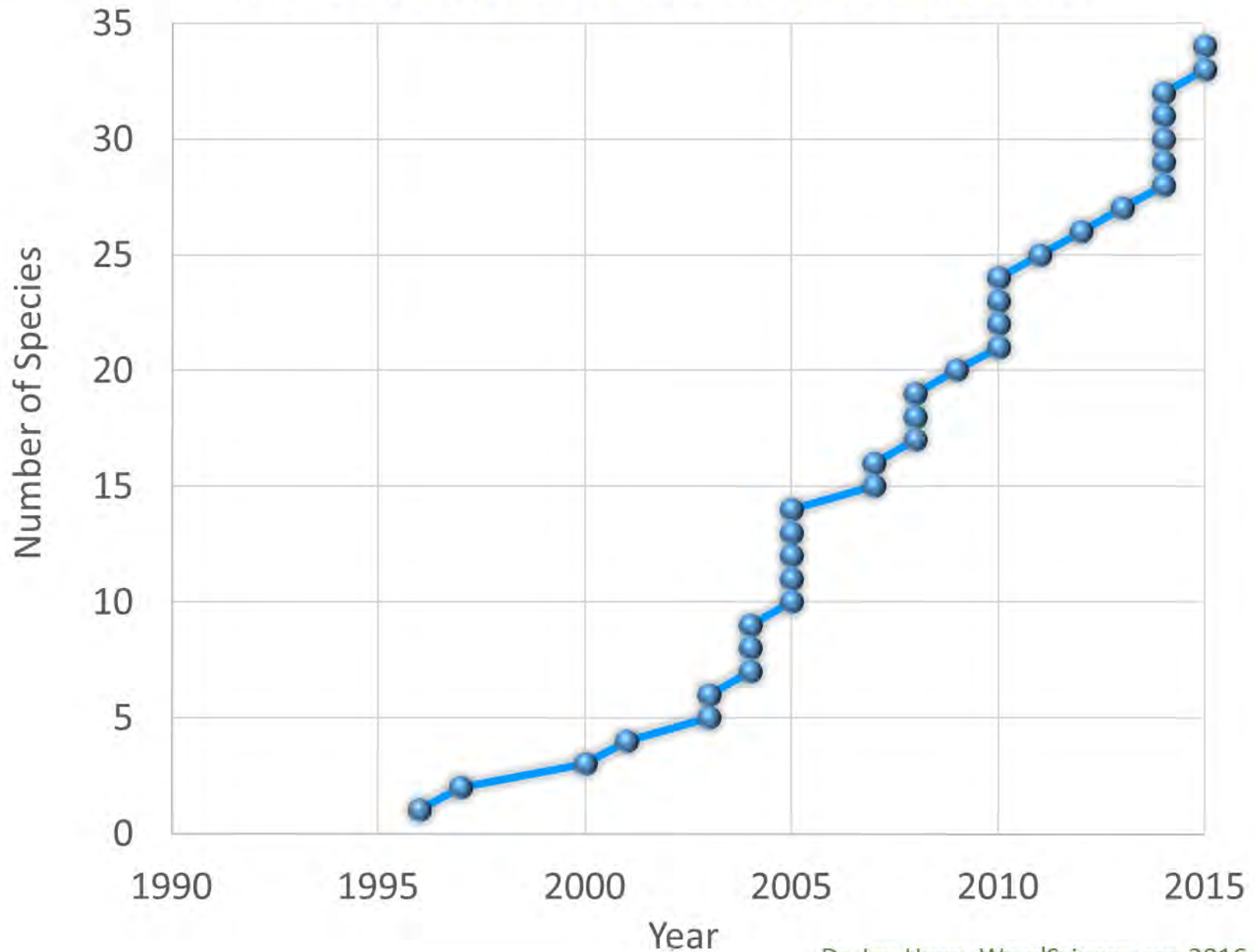
Number of Herbicide Resistant Weed Species by Weed Family (Top 10)



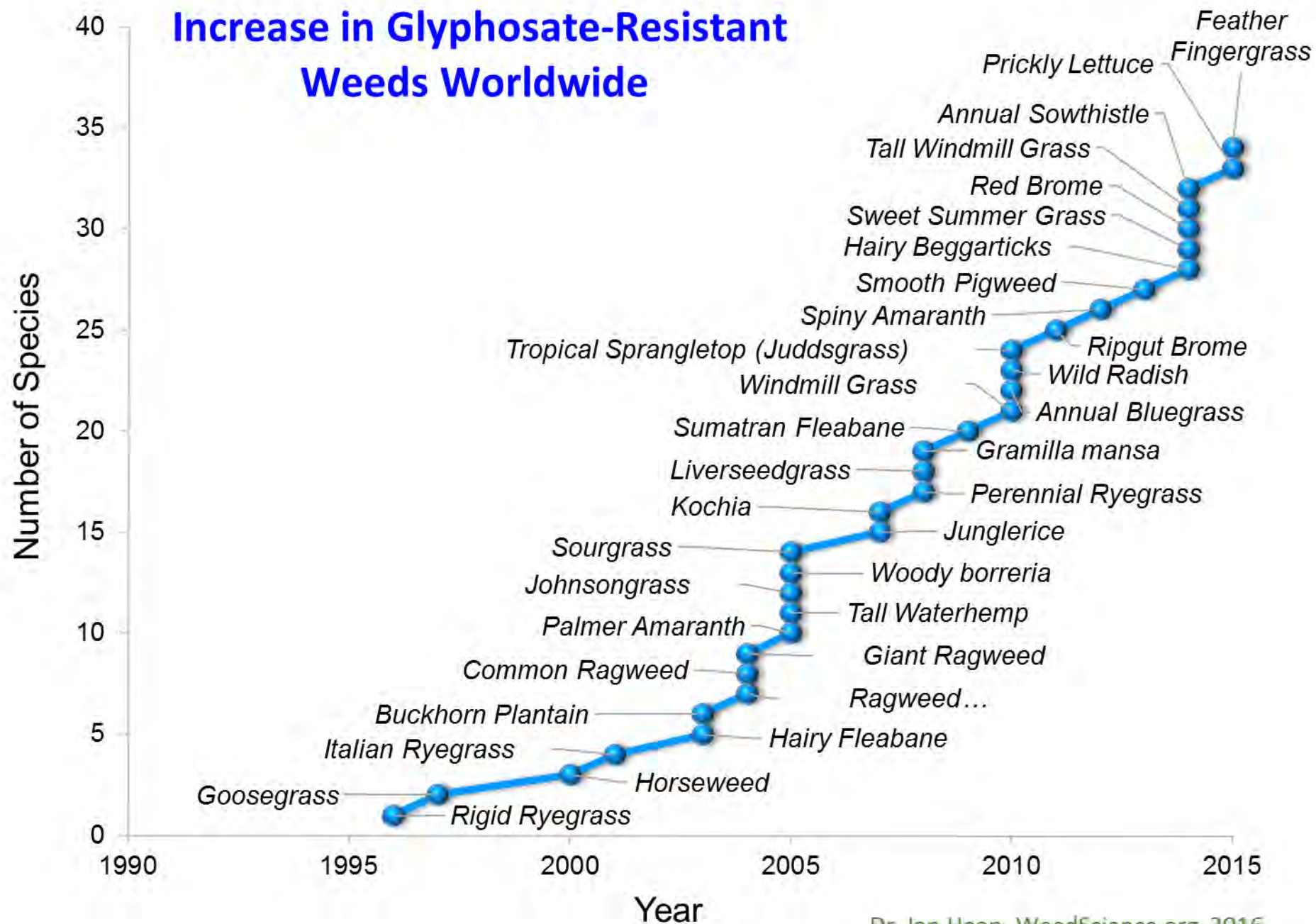
Number of Herbicide-Resistant Species by Crop



Increase in Glyphosate-Resistant Weeds Worldwide



Increase in Glyphosate-Resistant Weeds Worldwide



Herbicide Resistance Management

- Weed Management Practices:

- Monitor the sites of application.
- Evaluate your weed management program and standard practices.
- Incorporate other management options, where possible.

- Herbicide Related Practices:

- Understand and follow the label.
- Rotate herbicides
- Tank mix herbicides, of different modes of action.

Diversity of Practices

The best strategies to manage herbicide resistance in weeds are established on the concept of diversity.

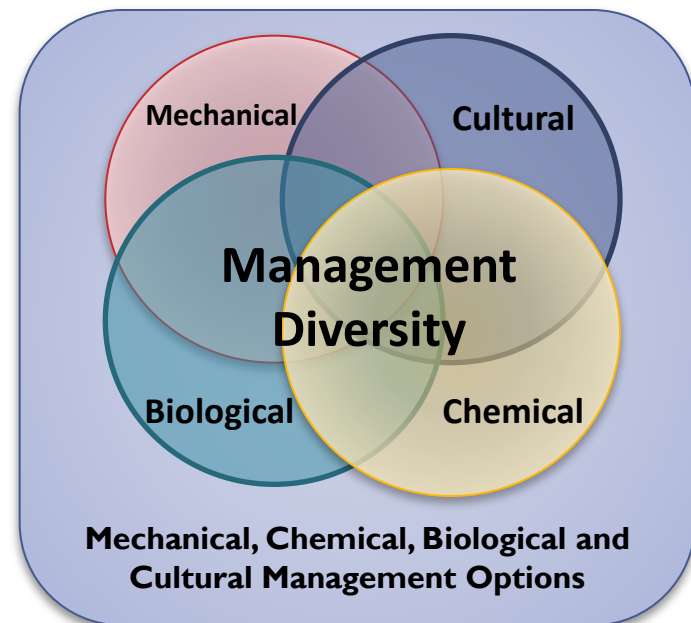
Diversity can be achieved by:

Using mechanical, cultural, and biological practices in addition to herbicides

and

Applying several herbicides with different mechanisms of action and overlapping control (each herbicide is active on the target weed or weeds)

A combination of tactics reduces the selection pressure imposed by any single practice.



Herbicide Resistance Management

- Herbicide Tank mixes/Mixtures:
 - Most reliable strategy in herbicide resistance management.
 - The success of a herbicide mixture depends upon each herbicide performing as effectively as it would when applied alone.
 - Mechanism of action
 - Efficacy (same weed spectrums)
 - Residual (persistence)

Categorization by Mechanism of Action

Summary of Herbicide Mechanism of Action According to the Weed Science Society of America (WSSA)

1

Acetyl CoA Carboxylase (ACCase) Inhibitors

Aryloxyphenoxypropionate (FOPs) cyclohexanedione (DIMs) and phenylpyrazolin (DENs) herbicides inhibit the enzyme acetyl-CoA carboxylase (ACCase), the enzyme catalyzing the first committed step in *de novo* fatty acid synthesis (Burton 1989; Focke and Lichtenthaler 1987). Inhibition of fatty acid synthesis presumably blocks the production of phospholipids used in building new membranes required for cell growth. Broadleaf species are naturally resistant to cyclohexanedione and aryloxyphenoxy propionate herbicides because of an insensitive ACCase enzyme. Similarly, natural tolerance of some grasses appears to be due to a less sensitive ACCase (Stoltenberg 1989). An alternative mechanism of action has been proposed involving destruction of the electrochemical potential of the cell membrane, but the contribution of this hypothesis remains in question.

2

Acetolactate Synthase (ALS) or Acetohydroxy Acid Synthase (AHAS) Inhibitors

Imidazolinones, pyrimidinylthiobenzoates, sulfonylaminocarbonyl triazolinones, sulfonylureas, and triazolopyrimidines are herbicides that inhibit acetolactate synthase (ALS), also called acetohydroxyacid synthase (AHAS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine, and valine (LaRossa and Schloss 1984). Plant death results from events occurring in response to ALS inhibition and low branched-chain amino acid production, but the actual sequence of phytotoxic processes is unclear.

3

15

23

Mitosis Inhibitors

Benzamide, benzoic acid (DCPA), dinitroaniline, phosphoramidate, and pyridine herbicides (Group 3) are

The numbering system assigns each herbicide to a mechanism of action group.

[Link to herbicide mechanism of action classification](#)

The EPA recommends that labels display the group number that identifies the mechanism of action for the active ingredient(s) in a formulated product.

Examples of Mechanism of Action on Labels

GROUP 9 HERBICIDE

The product with this symbol on the label contains glyphosate, an active ingredient in Group 9; the mechanism of action is binding to the EPSP synthase enzyme resulting in inhibition of aromatic amino acid formation.

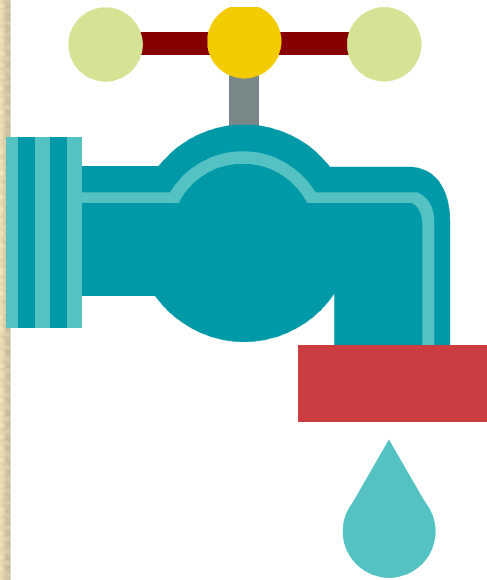
GROUP 5 HERBICIDE

The product with this symbol on the label contains atrazine, an active ingredient in Group 5; the mechanism of action is binding to the Q_8 -binding niche on the D1 protein of the photosystem II complex in the chloroplast thylakoid membranes resulting in inhibition of photosynthesis.

GROUP 15 9 27 HERBICIDE

The product with this symbol contains s-metolachlor, glyphosate, and mesotrione, active ingredients with three different mechanisms of action, designated by Group 15 - inhibition of very long chain fatty acids resulting in inhibition of cell division; Group 9 - binding to the EPSP synthase enzyme and Group 27 – inhibition of 4-HPPD resulting in bleaching of the plants, respectively.

Why should we care about weeds developing resistance?



- Consolidation of industry
 - 20+ companies in 1984
 - Major players today?
- Herbicide development is much less profitable than it used to be.
 - Takes \$200 million + and 9 years to bring a new herbicide to market.
- The pipeline for new products has slowed down, with fewer new active ingredients.
- Take good care of the existing products available to us.