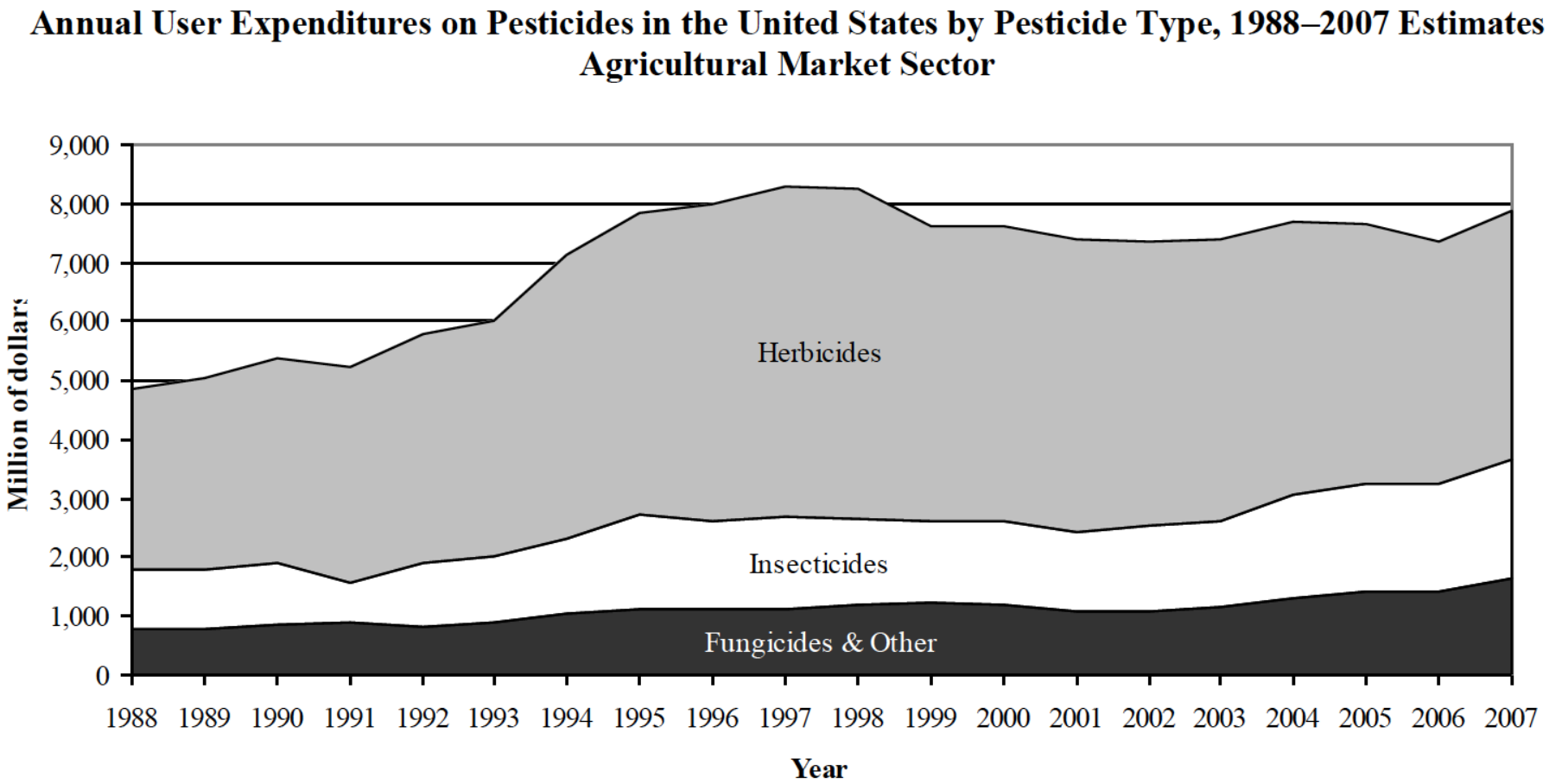
Addressing herbicide-resistant weeds epidemic with Integrated Weed Management

S.B. Mirsky, J.K. Norsworthy, A.S. Davis, M.V. Bagavathiannan, S.C. Beam, J.A. Bond, K. Bradley, W.S. Curran, J. Evans, W. Everman, M.L. Flessner, G. Frisvold, N.R. Jordan, L.M. Lazaro, J. Lindquist, L. S. Shergill, L.E. Steckel, M.J. VanGessel

How important are weeds?

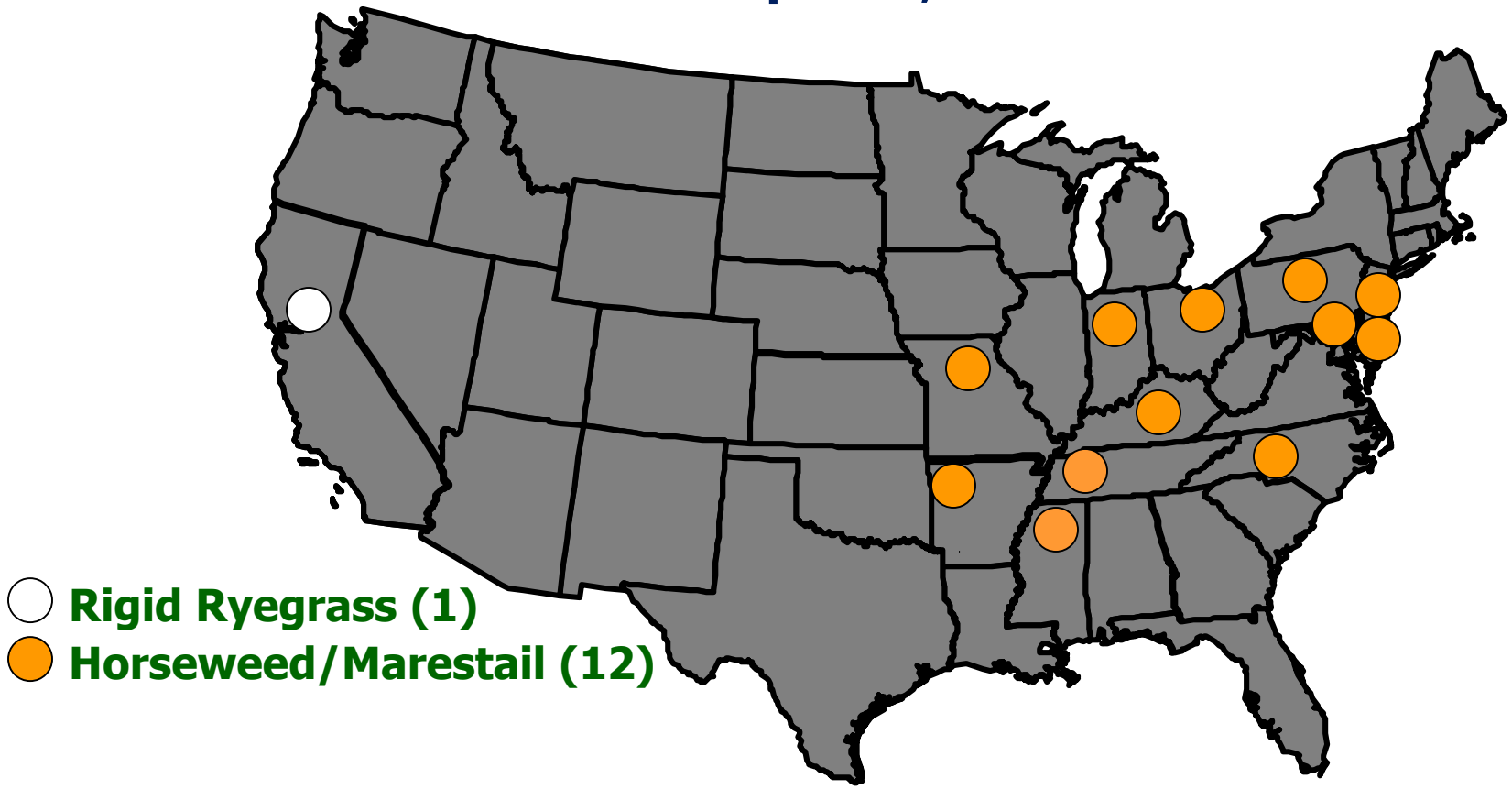
Herbicides represent the highest expenditure for pest management in US agriculture



Source: EPA-Pesticides industry sales and usage: 2006 and 2007 estimates

Glyphosate-resistant Weeds in the U.S.

2003: 2 species; 13 states



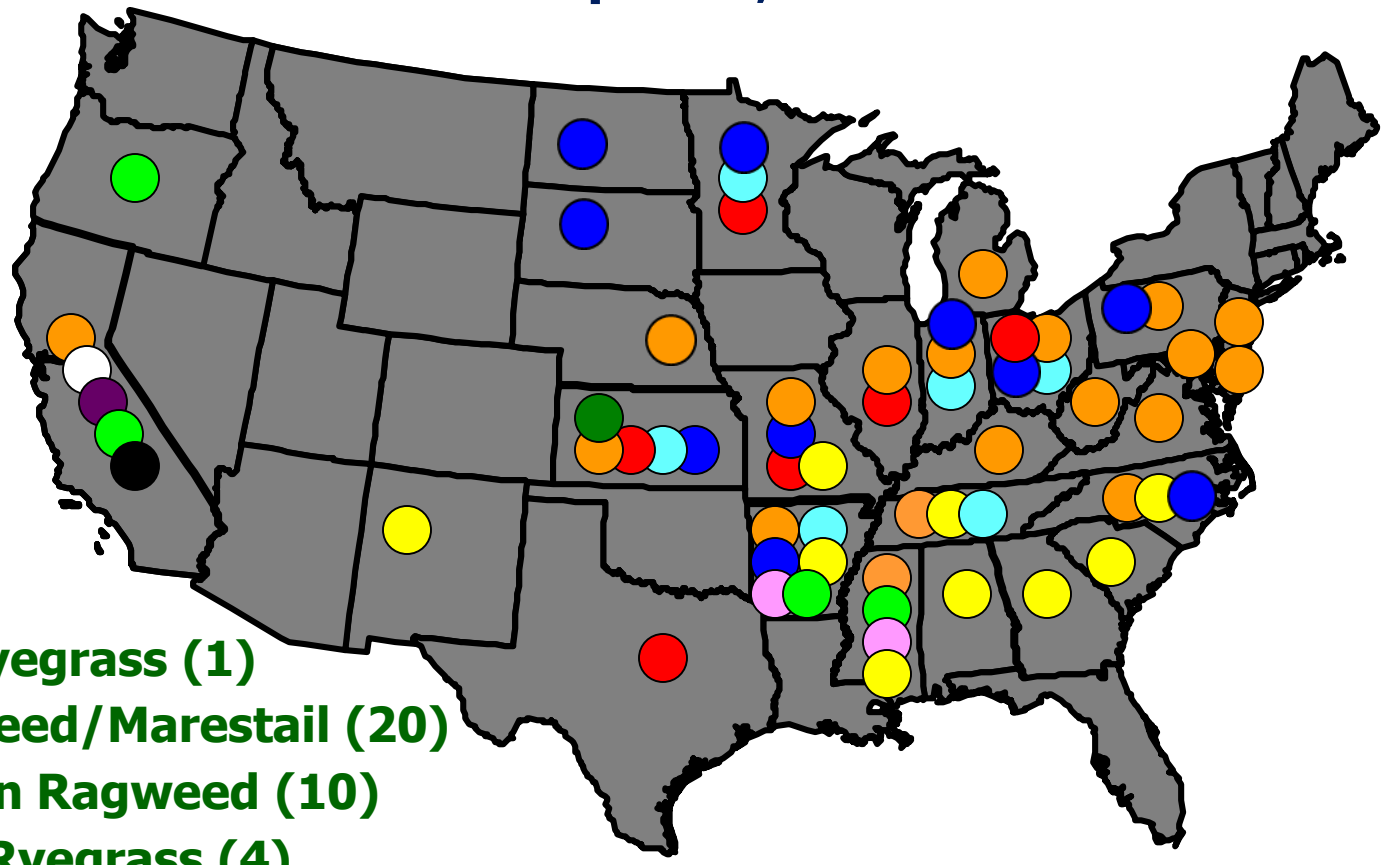
○ Rigid Ryegrass (1)

● Horseweed/Marestail (12)

*Parentheses indicate the number of states in which that resistant weed occurs

Glyphosate-resistant Weeds in the U.S.

2008: 11 species; 28 states

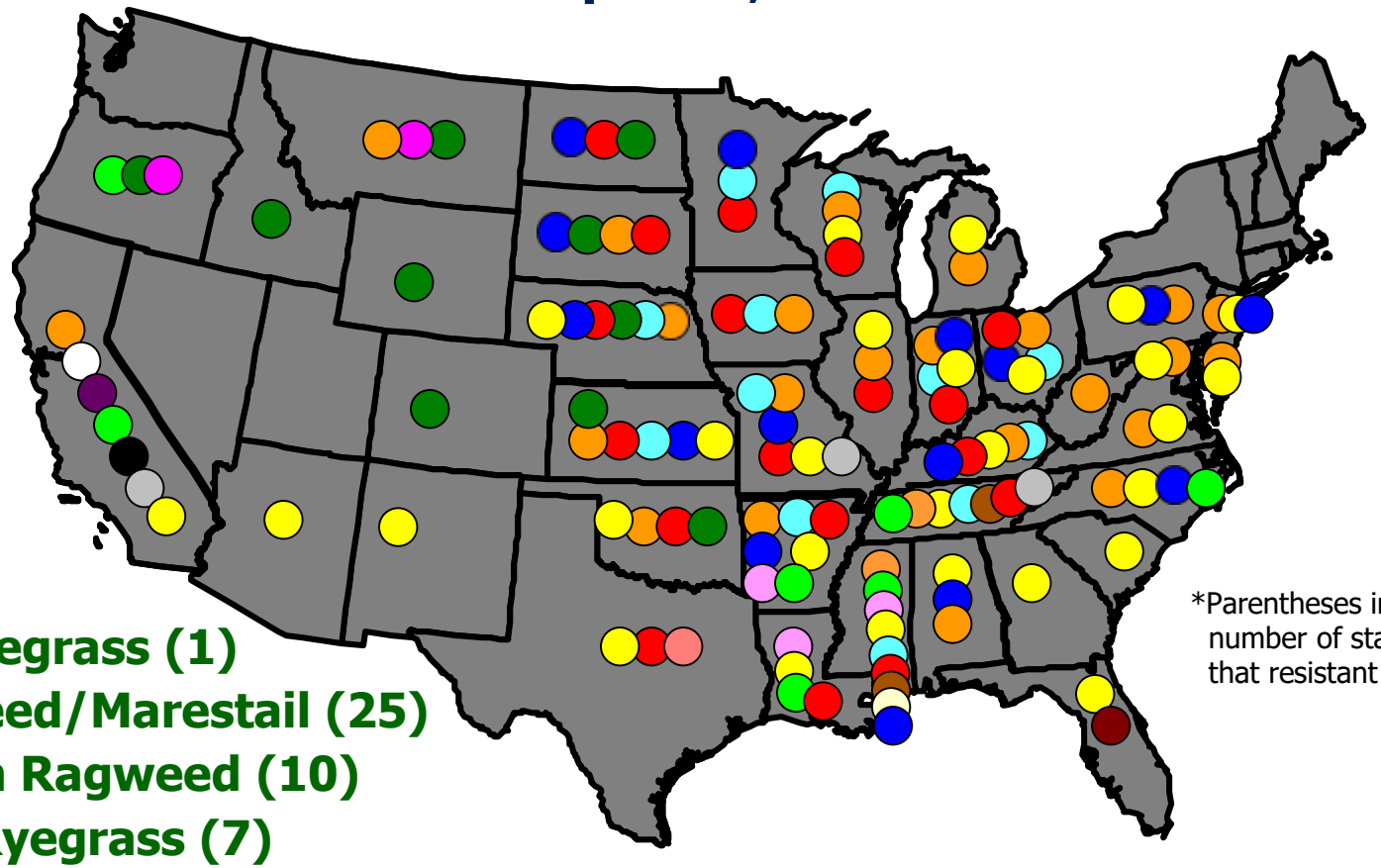


- Rigid Ryegrass (1)
- Horseweed/Marestail (20)
- Common Ragweed (10)
- Italian Ryegrass (4)
- Giant Ragweed (8)
- Waterhemp (8)
- Palmer amaranth (9)
- Hairy Fleabane (1)
- Johnsongrass (2)
- Kochia (2)
- Junglerice (1)

*Parentheses indicate the number of states in which that resistant weed occurs

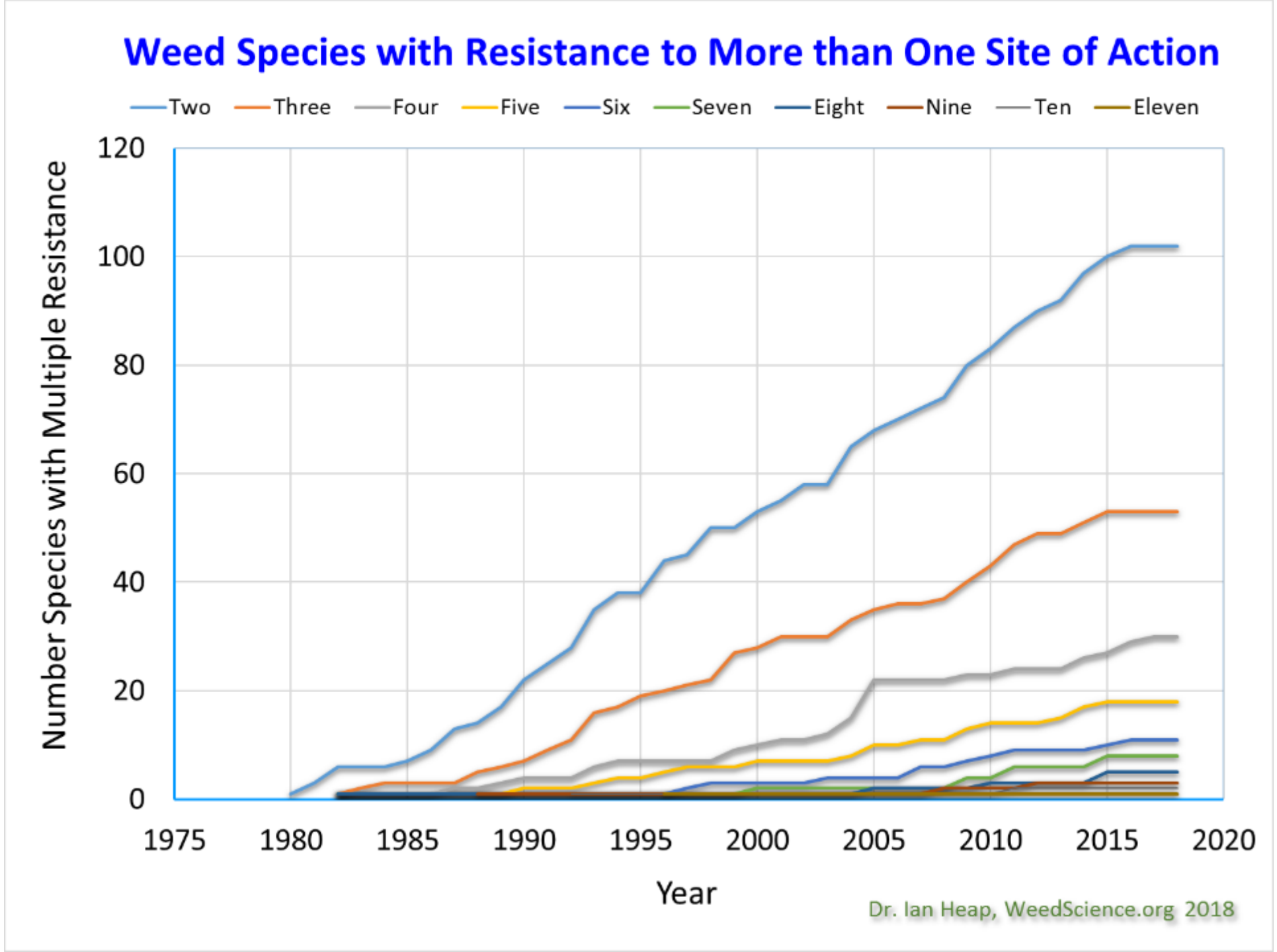
Glyphosate-resistant Weeds in the U.S.

2018: 17 species; 38 states



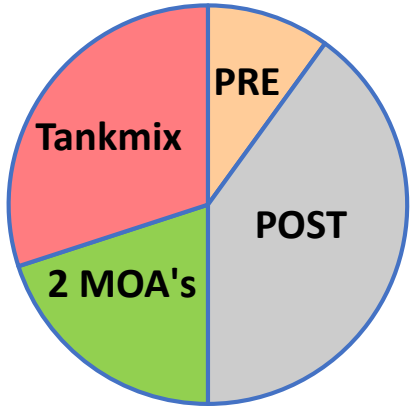
*Parentheses indicate the number of states in which that resistant weed occurs

- Rigid Ryegrass (1)
- Horseweed/Marestail (25)
- Common Ragweed (10)
- Italian Ryegrass (7)
- Giant Ragweed (12)
- Waterhemp (18)
- Palmer amaranth (28)
- Hairy Fleabane (1)
- Johnsongrass (3)
- Kochia (10)
- Junglerice (1)
- Ann. Bluegrass (3)
- Goosegrass (2)
- Spiny Amaranth (1)
- Russian Thistle (2)
- Ragwd Parthenium (1)
- Common Sunflower (1)


Weed Species with Resistance to More than One Site of Action
Two
Three
Four
Five
Six
Seven
Eight
Nine
Ten
Eleven
Number Species with Multiple Resistance
120
100
80
60
40
20
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
Dr. Ian Heap, WeedScience.org 2018

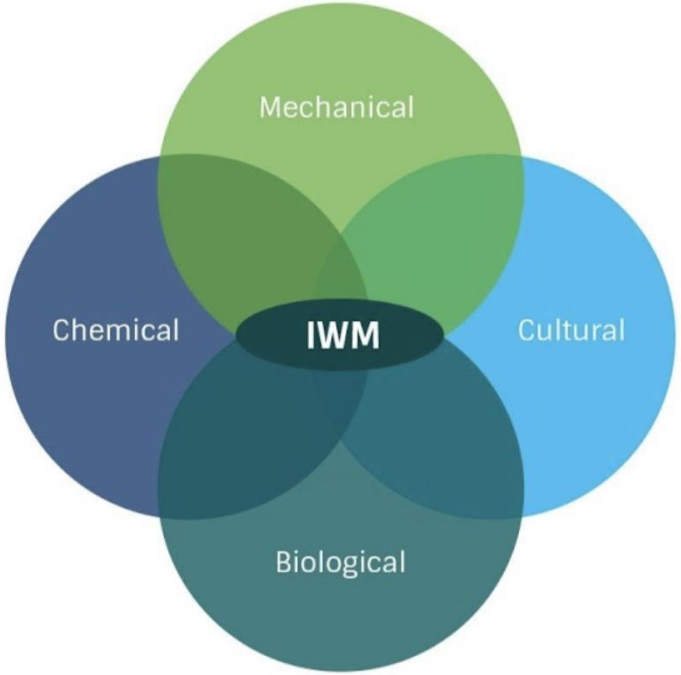
Integrated weed management (IWM): integrating multiple weed control tactics into a weed management program

Gene stacking and herbicide management



Multi-tactic approach

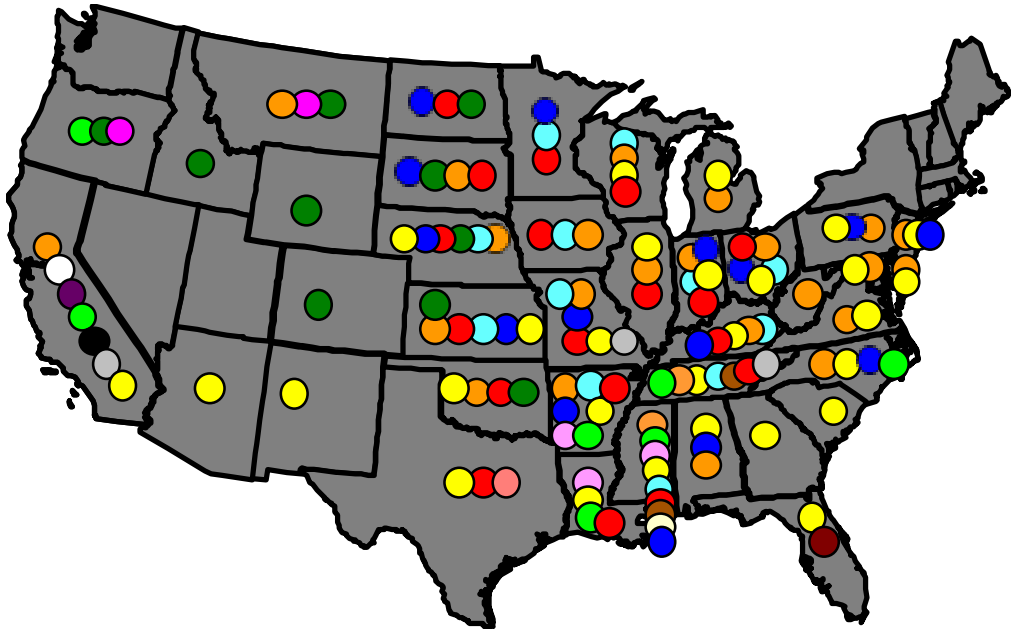
- Crop rotation
- Herbicides
- Cover crops
- Primary and secondary tillage
- Breeding (crop competitiveness and higher allelopathy)
- Cultural practices (i.e., planting dates, seeding rates, row spacing)
- Precision nutrient management
- Harvest weed seed control (HWSC)



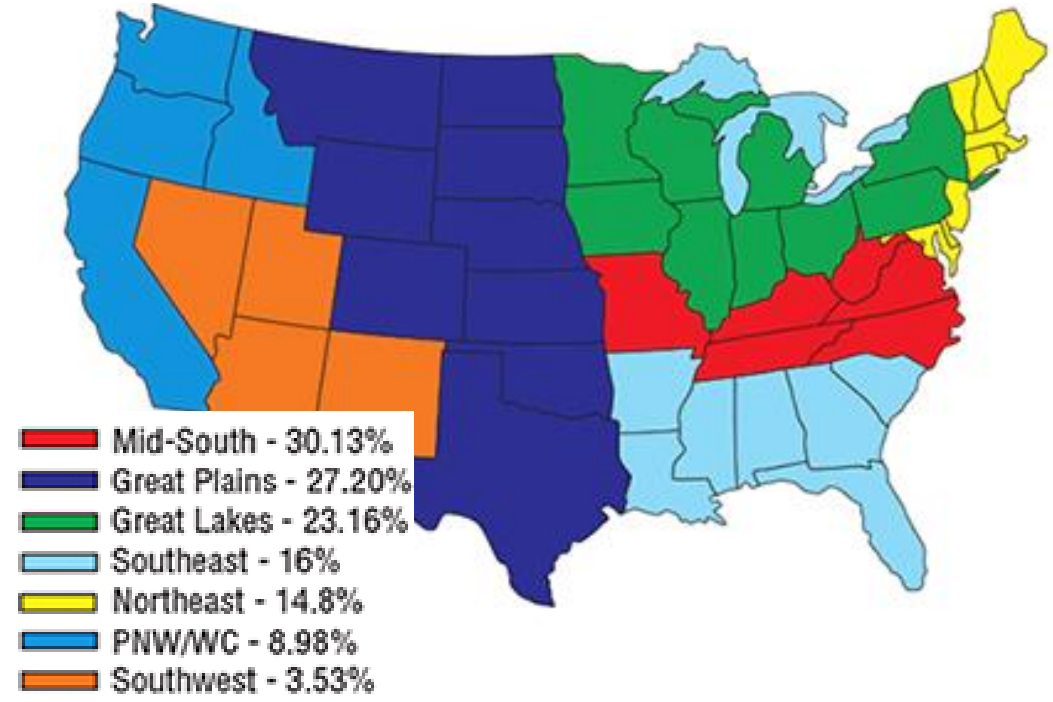
Integrated weed management

Manage weeds while conserving soil resources

Glyphosate-resistant Weeds



No-till Acreage (%; 2012 census)

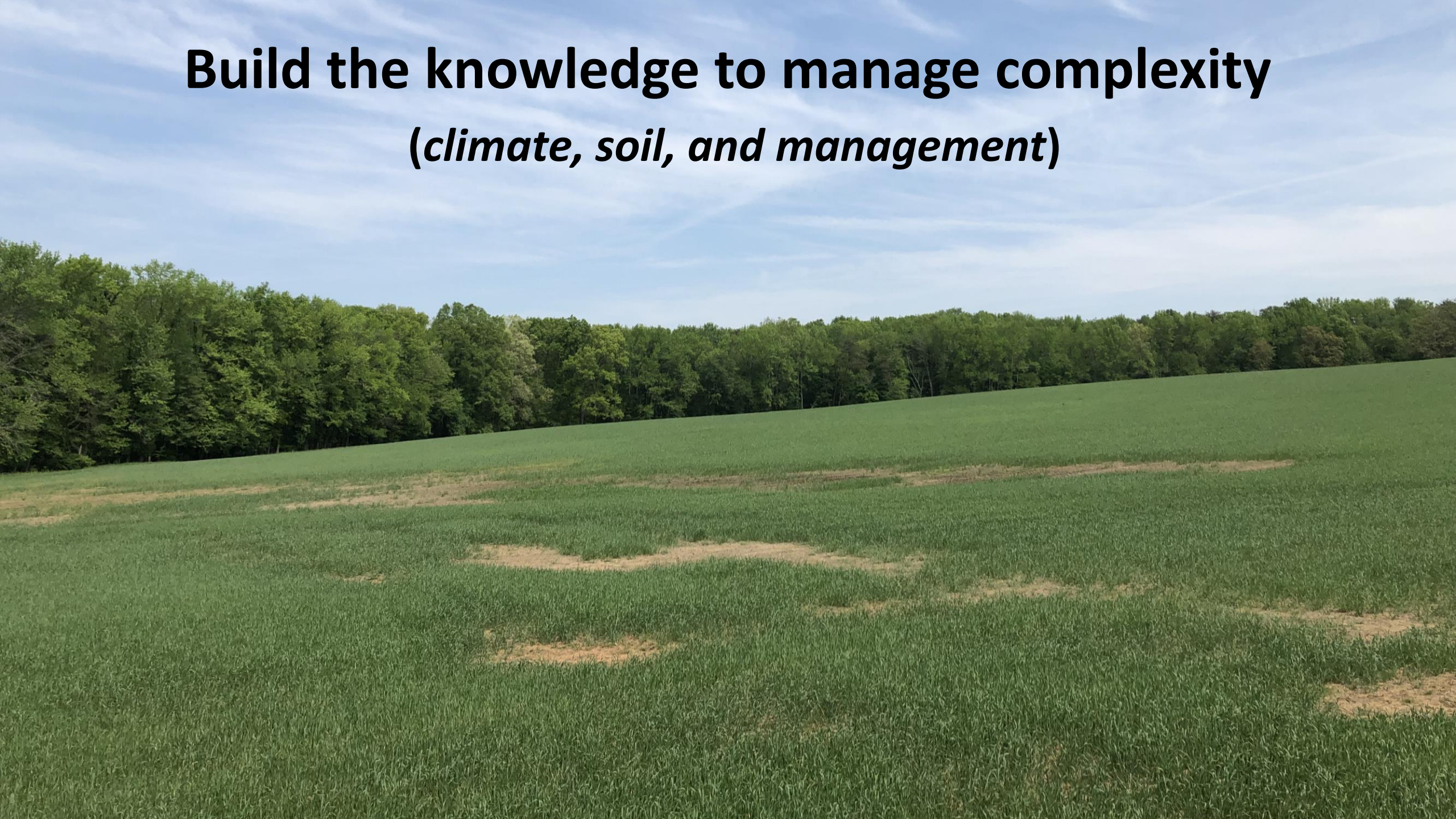


Integrated weed management requires geospatial solutions

Ecological strategies are complex, messy, and knowledge intensive

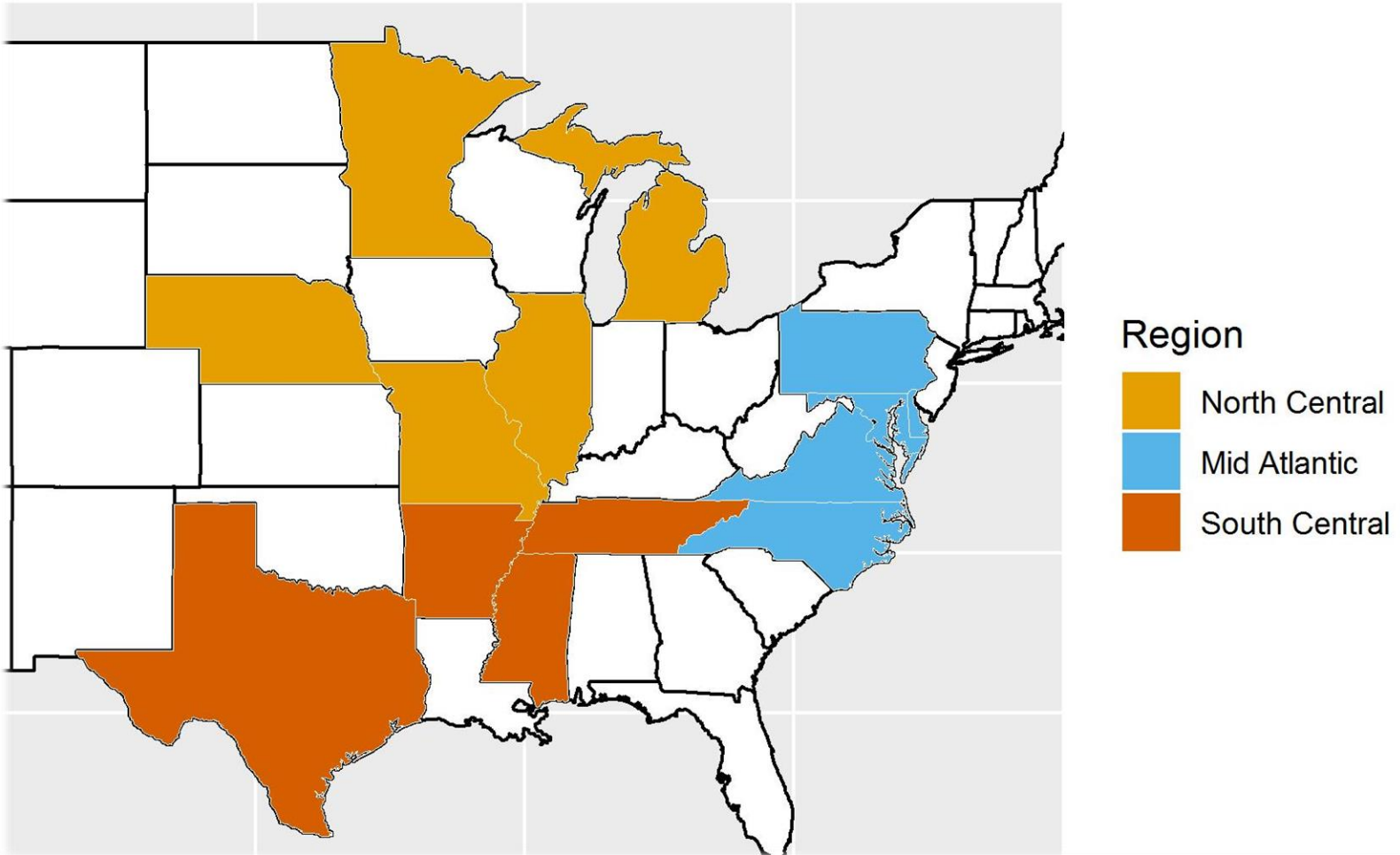
Build the knowledge to manage complexity

(*climate, soil, and management*)



Integrated weed management team

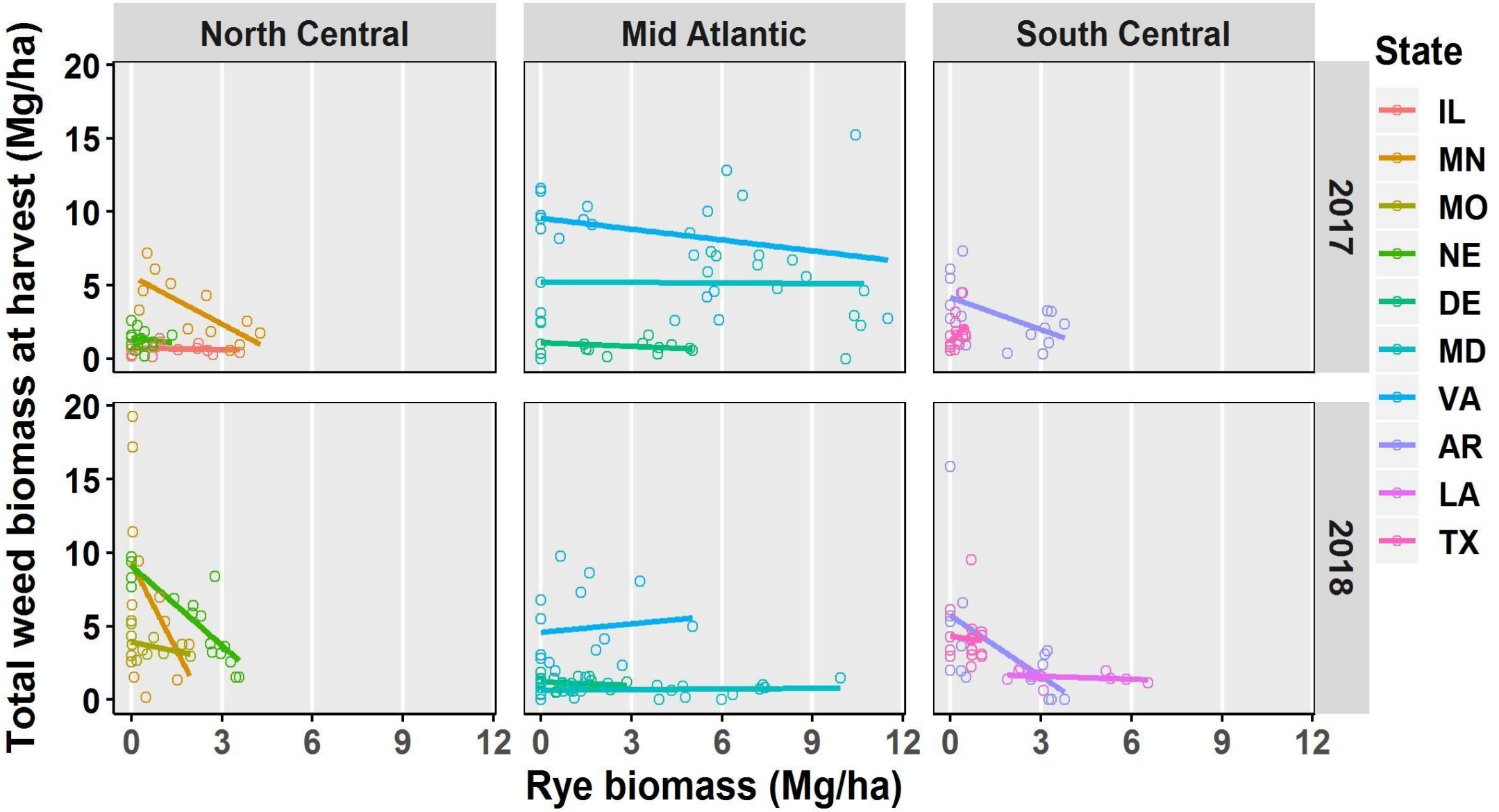
https://integratedweedmanagement.org



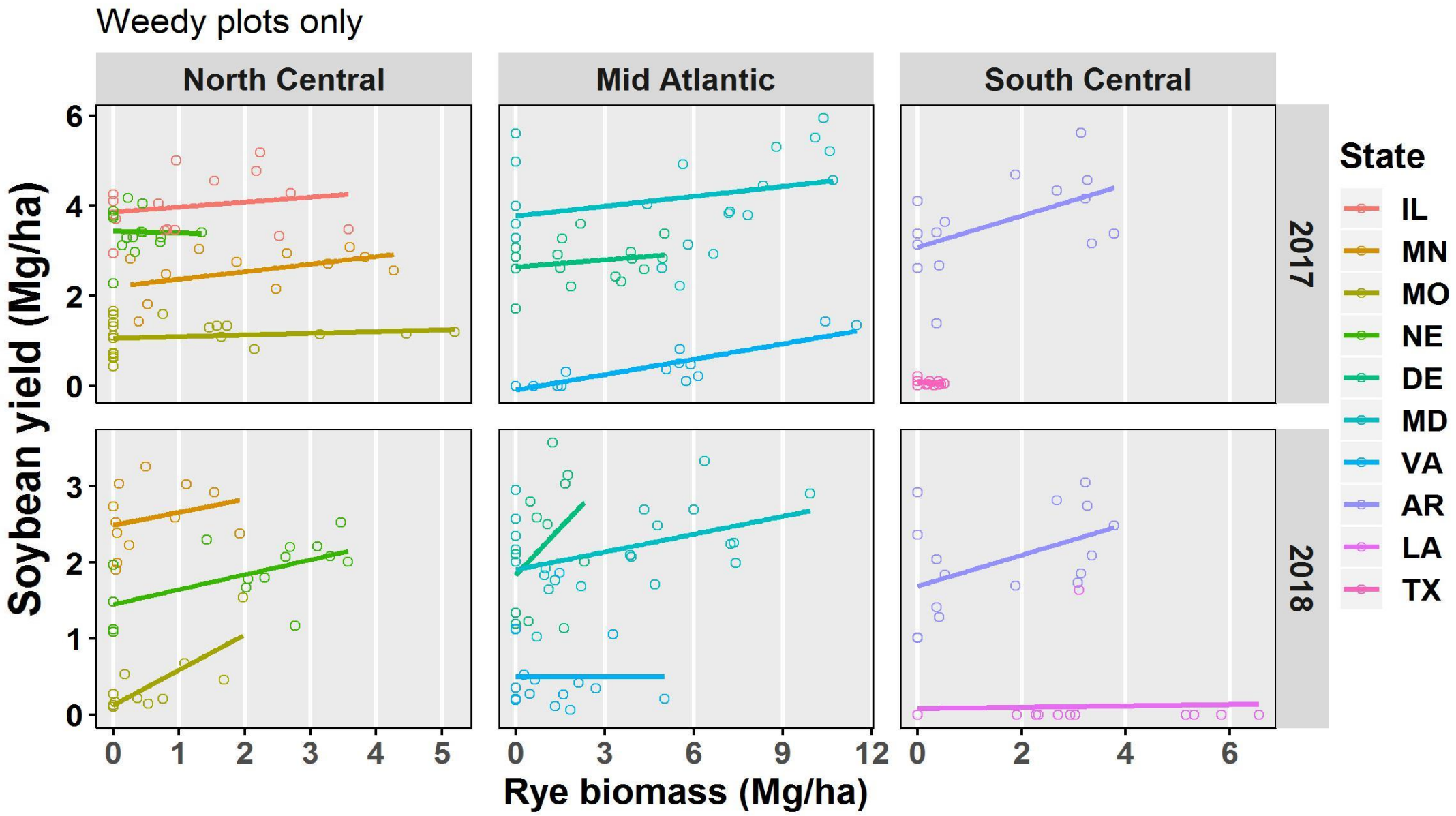
National Cover Crop*Herbicide Interactions study in Soybeans

- Initiated fall 2016 (45 site years)
- Gradients of cover crop biomass (termination dates)
- Three herbicide programs

Weed biomass as influenced by cereal rye biomass levels



Soybean yield as influenced by cereal rye biomass



Harvest Weed Seed Control (HWSC)


Chaff cart


Narrow windrow burning


Bale direct

HWSC systems (Similarly effective ~ 60% reduction in *L. rigidum*)


Chaff lining

Impact mills

Chaff tramlining

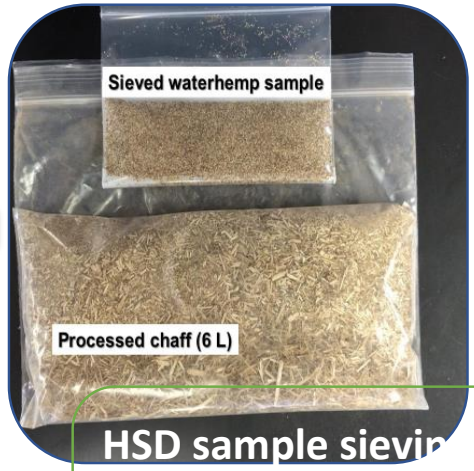
Walsh *et al*. (2017)

Stationary testing and seed burial study

Sample Prepar
- 7 weed species
- 500 seed/rep per specie, 8 reps
- 6L soybean chaff

Stationar
- Cage mill @1400 RPM

HSD sample
- Cloth bag

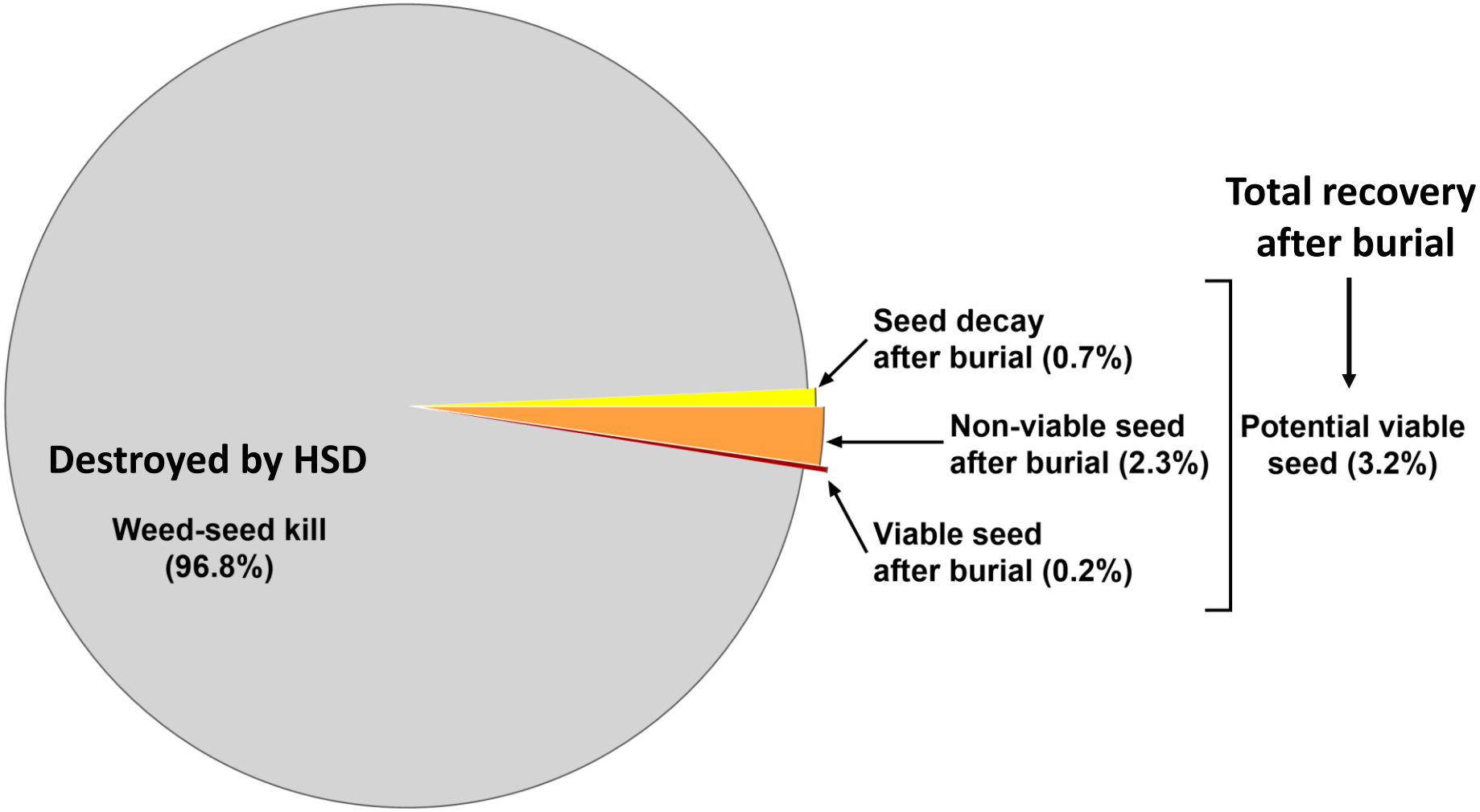


HSD sample sievi
- PVS; 50% of original seed size

Winter burial
- Buried PVS, wire envelopes
- 90d; 2” depth

Seed viability t
- Forceps crush test
- Razor blade “sheen” test

Weed seed fate after HSD and burial (90 days)



Harvest-Time Weed Seed Control (HWSC)

Integrated (iHSD)

Harrington Seed Destructor (HSD)

Weed seed rain

- Which weed species can we target with HWSC?
- When is the point of no return for the soil seedbank?

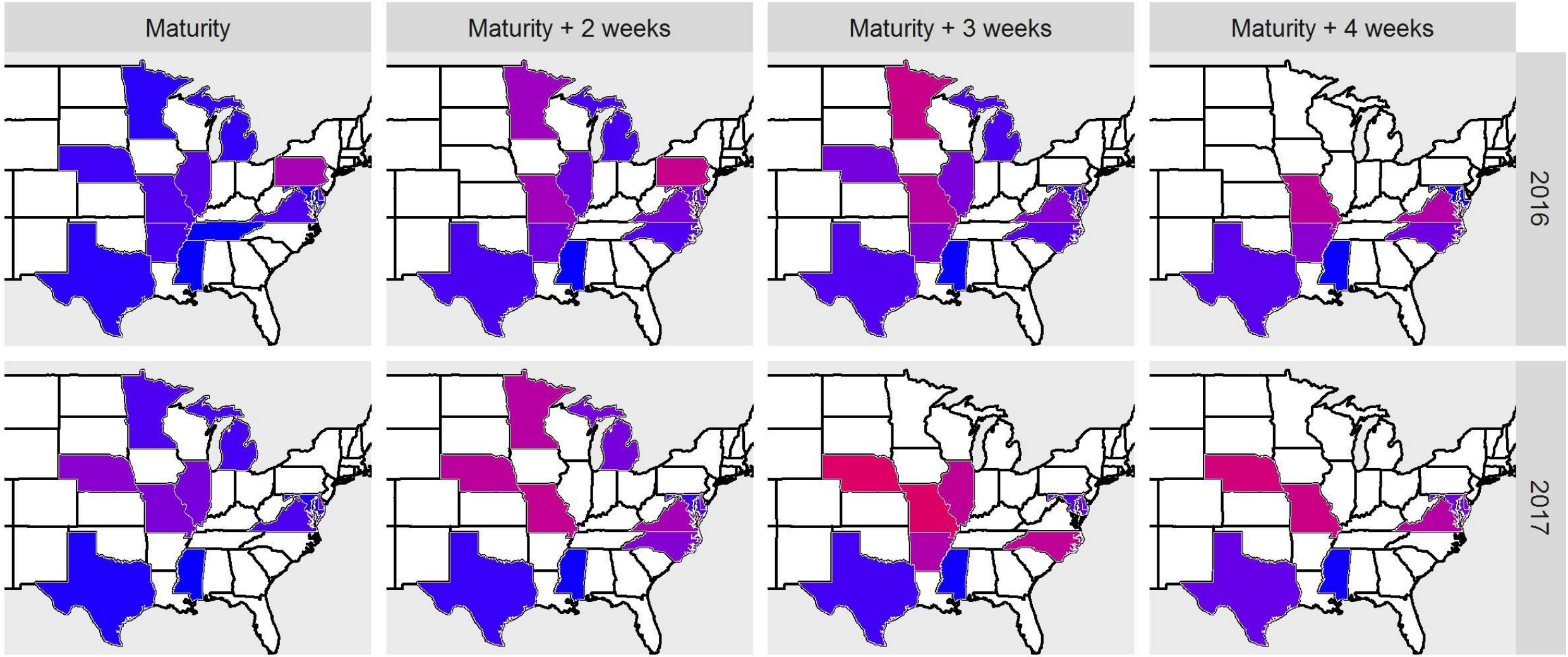




Target Weed Species

common ragweed
common lambsquarters
giant, green, and yellow foxtail
sicklepod
Palmer amaranth
common cocklebur
sicklepod
redroot and smooth pigweeds
Jimsonweed
large crabgrass
common waterhemp
velvetleaf
wild proso millet and Texas millet
barnyardgrass
hemp sesbania
ivyleaf, and pitted morningglory
prickly sida
johnsongrass
giant ragweed

Cumulative % weed seed shatter (broadleaves)



Long-term Agricultural Research (IWM trials)

- Corn-soybean rotation (since 2015)
- Harvest weed seed control, herbicides, cover crops, and tillage

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Getting Rid Of Weeds
Through Integrated Weed Management

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WHAT IS INTEGRATED WEED MANAGEMENT?

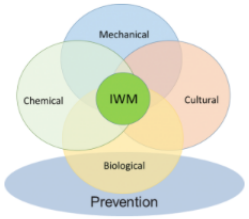
> ***Weed management is most effective when it integrates a combination of strategies, based on what works best for achieving a particular management goal while maintaining economic and environmental stability. Common methods span a large range and include prevention and cultural, chemical, mechanical, and biological practices.***

Integrated weed management (IWM) means integrating multiple methods to manage weeds, using the combination of practices that is most effective for solving the specific weed issue at hand.

These weed management techniques form a "toolbox" in which each "tool" can be integrated into a weed management plan catered to the particular farm and problem. The toolbox includes chemical (herbicide), mechanical, cultural, biological practices, and prevention of weed introduction and spread.

IWM tactics span a wide range of types and complexity. Not all IWM tactics are very complex. Some examples include: equipment cleaning, timely scouting, altering herbicide tank mixes, rotating herbicides, cover cropping, changing tillage practices, and hand-pulling weeds.

Integrated weed management is **not** an alternative to herbicides in conventional crops. For many decades, herbicides have been the primary means of weed management in conventional crops due to their simplicity, effectiveness, and affordability. IWM is about using all options available to best solve the problem – in many cases in conventional crops, herbicides are part of this solution.



The 5 types of management tactics that can be used in integrated weed management.
Illustration: Annie Klodd

PREVENTION: Monitor inputs to the farm to avoid bringing in things that may be contaminated with weed seeds. To do this, learn how key weeds are spread and whether those weeds are located in areas that the farm is transporting supplies from. Equipment, manure, feed, and crop seed are primary spreaders of weeds. Spread via wind and wildlife is more common for some weed species than others. State-level herbicide resistant weed lists are at weedscience.org.

CHEMICAL: Herbicides are a key part of IWM in conventional and some organic systems. In conventional crops, using **multiple effective herbicide modes of action** (MOA) is essential for effective control of resistant weeds. This involves combining multiple MOA in tank mixes, and varying MOA between applications and seasons. For MOA with high occurrences of resistant weeds, avoid repeat use in consecutive seasons.

CULTURAL: Cultural tactics are crop management decisions that help the crop be
help optimize the effectiveness of herbicide applications. Common examples inclu
crop rotation, crop variety selection, timing of planting, and cover cropping. Inforn
weed management is found throughout this site (Hover on the Weed Management

MECHANICAL: Common mechanical tools to disrupt weed growth and survival include cultivation, tillage, burning, and

TWITTER

Tweets by @GetRidOfWeeds

GROW.IWM @GetRidOfWeeds

GROW is "International " our website is mentioned in one of the largest soybeans and corn producers of the world we help to @GetRidOfWeeds through #integratedweedmanagement abroad thanks for that @hhdospierre ! clarin.com/rural/manejo-i...

23m

GROW.IWM @GetRidOfWeeds

Three previously cleaned combines were tested for weed seed retention, straw bales and wood chips were fed through the combine in an attempt to catch and remove any remaining weed seed. See how at

Embed View on Twitter

FIND YOUR WEED ID GUIDE

Go to Our Weed Id Section and Find One For Your Region

VIDEOS


Harvest Weed Seed Control

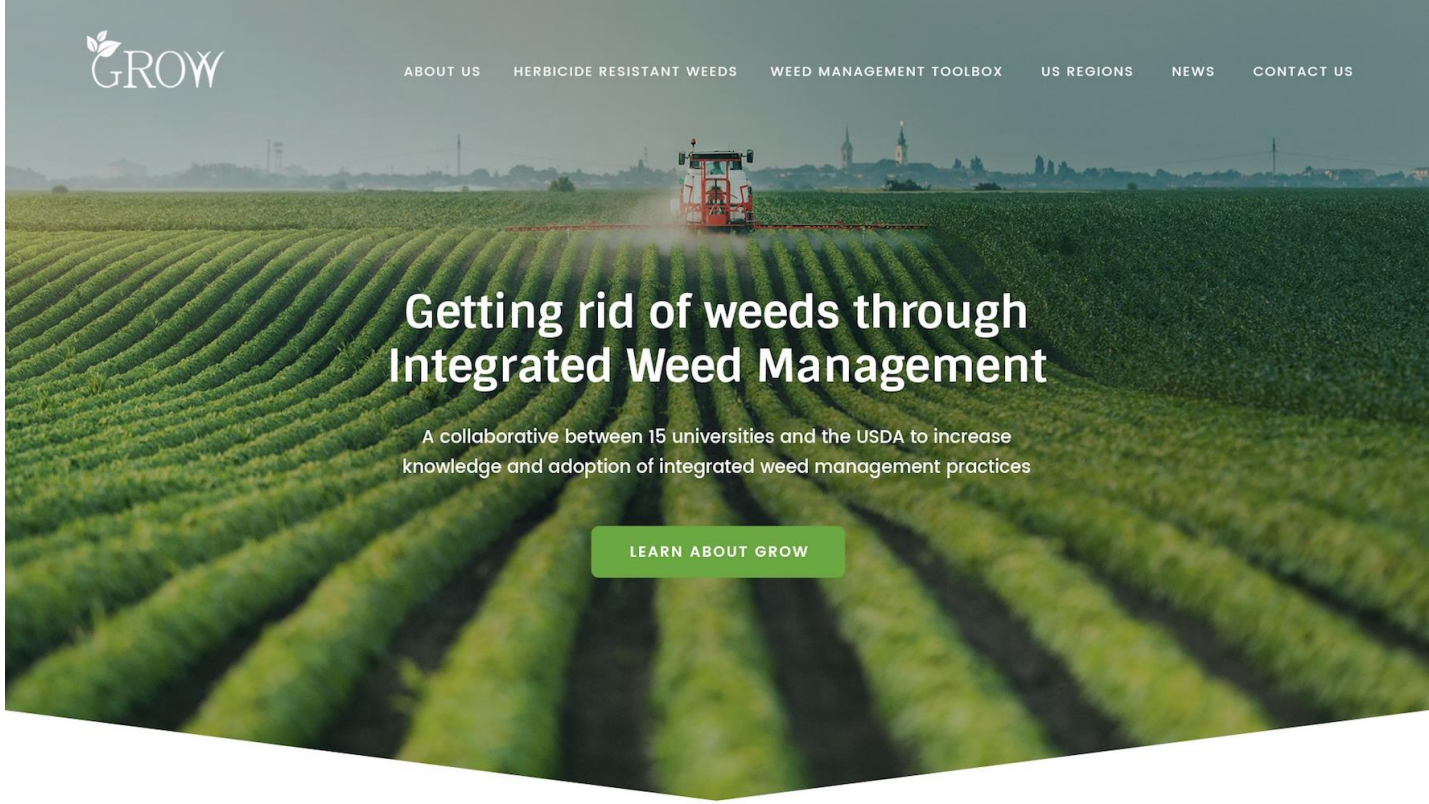

Resistance Management


Harrington Seed Destructor


Rolling Down Cover Crops

HERBICIDE RESISTANCE MANAGEMENT

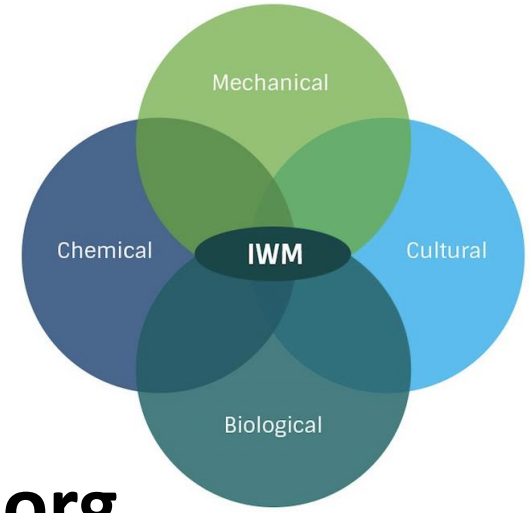
Prevention



What is Integrated Weed Management?

Since the 1940s, herbicides have been the cheap and effective way for farmers to control weeds and increase yields. In 2019, herbicide resistance is growing and effectiveness is dropping. While at the same time, food prices, food demand, land-use constraints, and other factors are all demanding that America's farmers make more with less.

For some farmers, herbicides alone just aren't getting the job done anymore. Integrated Weed Management (IWM) is the answer. IWM is the practice of combining multiple techniques to increase the effectiveness of, but not necessarily replace, herbicide use.



https://integratedweedmanagement.org

In the Fields

What is Growing on Your Farm?

Barnyardgrass
Echinochloa crus-galli

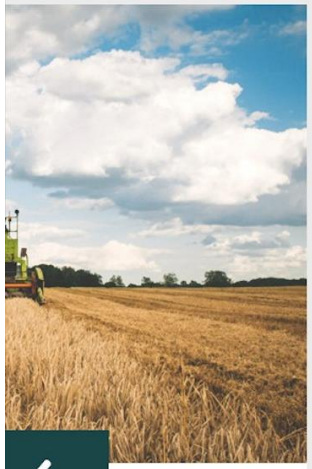
Common Ragweed
Ambrosia artemisiifolia

Giant Foxtail
Setaria faberi

Morning Glory
Ipomoea

https://integratedweedmanagement.org

IWM News



f Action to
sistance

rs has shed light on how
rather than rotate
pecies become visible in
sen to combat that...

Harvest is Coming, Avoid Adding to the Seed Bank

SEPTEMBER 10, 2019

As cash crop harvest approaches you may discover that weeds have escaped your control efforts and are setting seeds. These weeds may be very visible, poking their heads above the canopy of the cash crop. When you...

READ MORE

Air Seeding Cover Crops Ahead of Harvest

SEPTEMBER 2, 2019

Achieving a good cover crop stand is sometimes challenging, particularly when there is a short time period to get the field seeded. Farmers across the northern corn regions of the US have a small window of opportunity...

READ MORE

Understandi
Integrated Weed Mar

AUGUST 7, 2019

Understanding of the weed
successfully using integrat
seeds are deposited into t
season and are the source

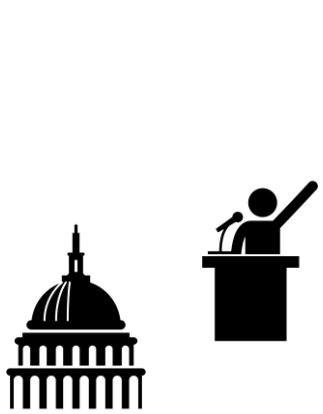
READ MORE

READ MORE IWM NEWS

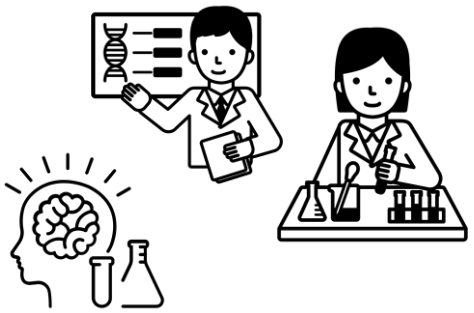
https://integratedweedmanagement.org

Decision support tools and models serving all stakeholders

(Expert opinion, empirical and process-based models, ML and hybrid models)



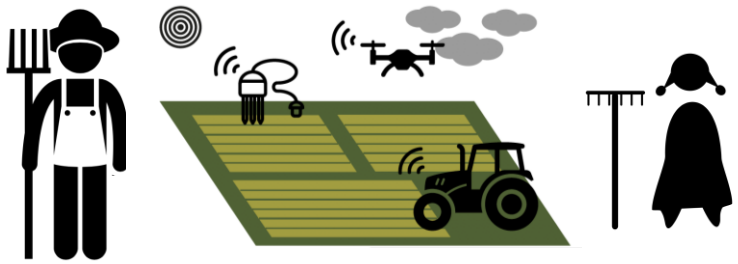
Inform policy makers



Researchers (what if?)

Technology transfer

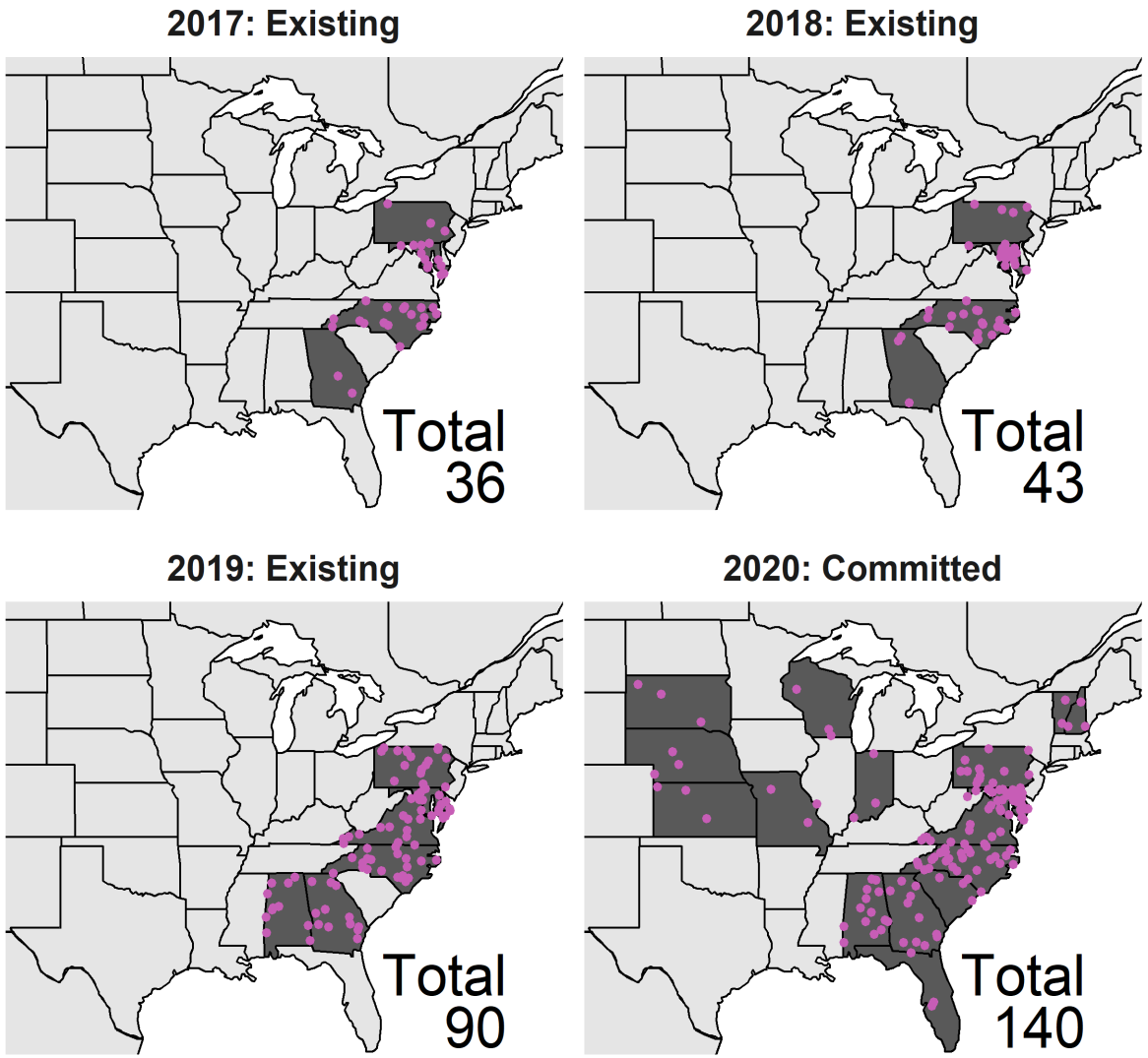
(USDA-NRCS, county agents, private consultants)

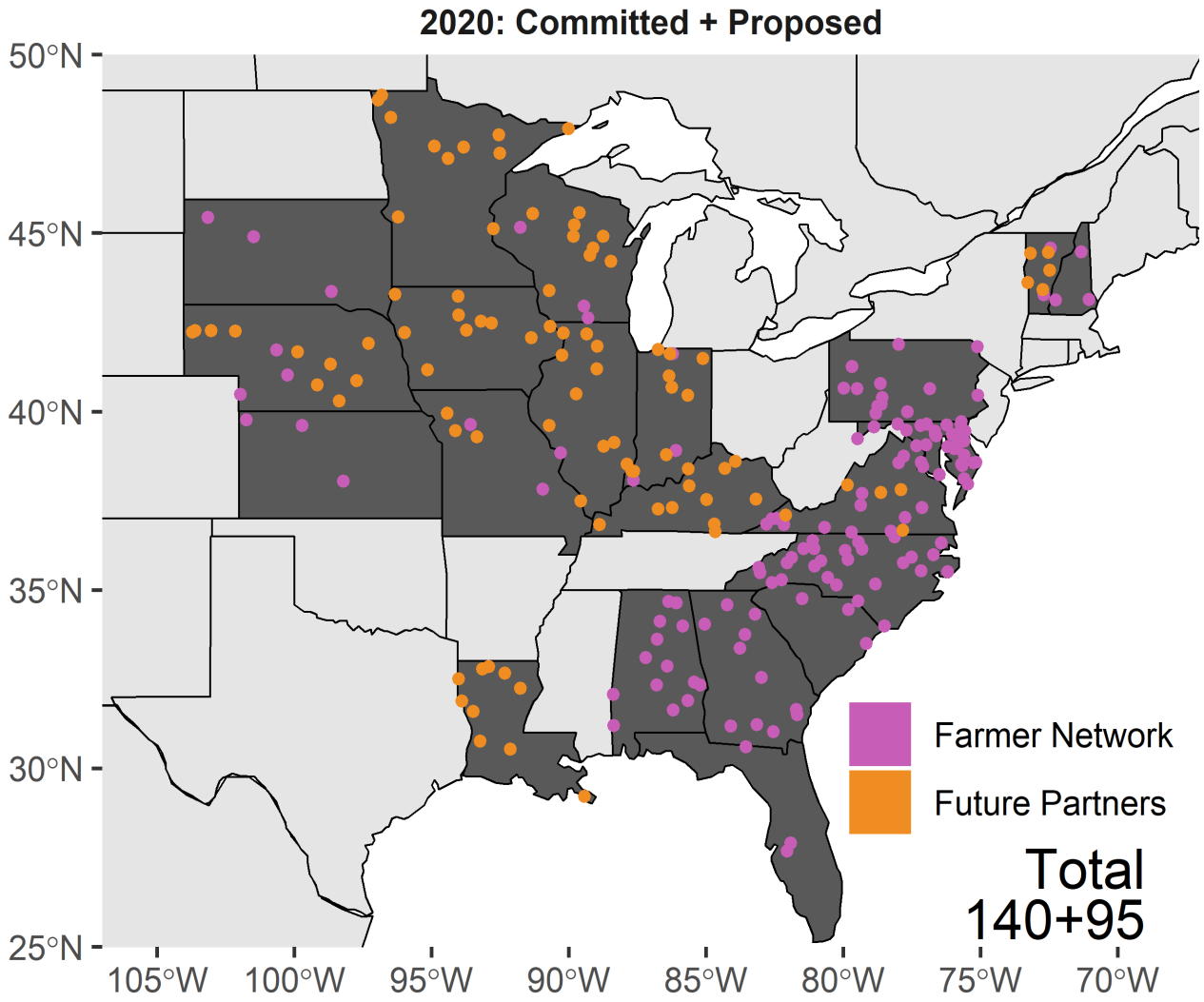


Farmers

(facilitate learning and decision making)

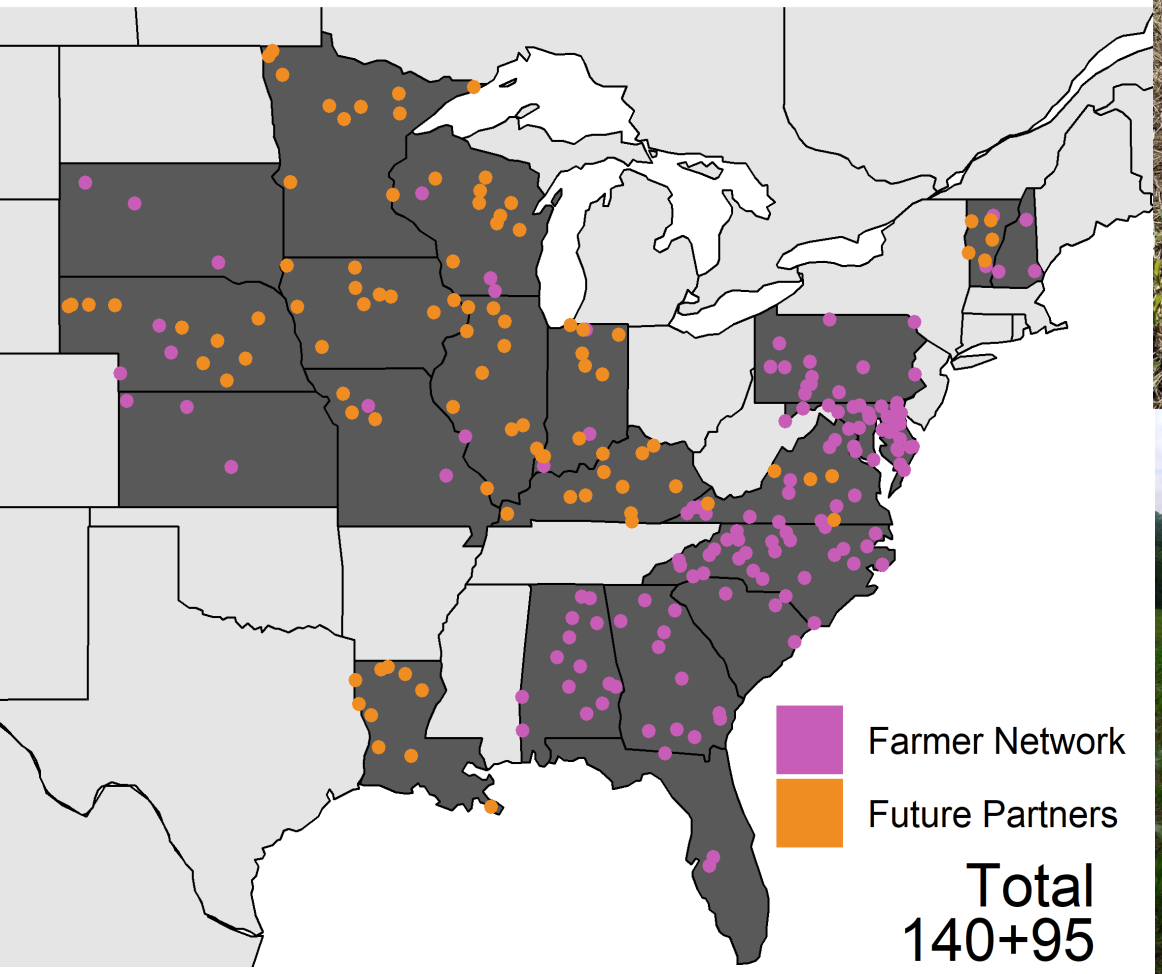
On-Farm Research and Monitoring



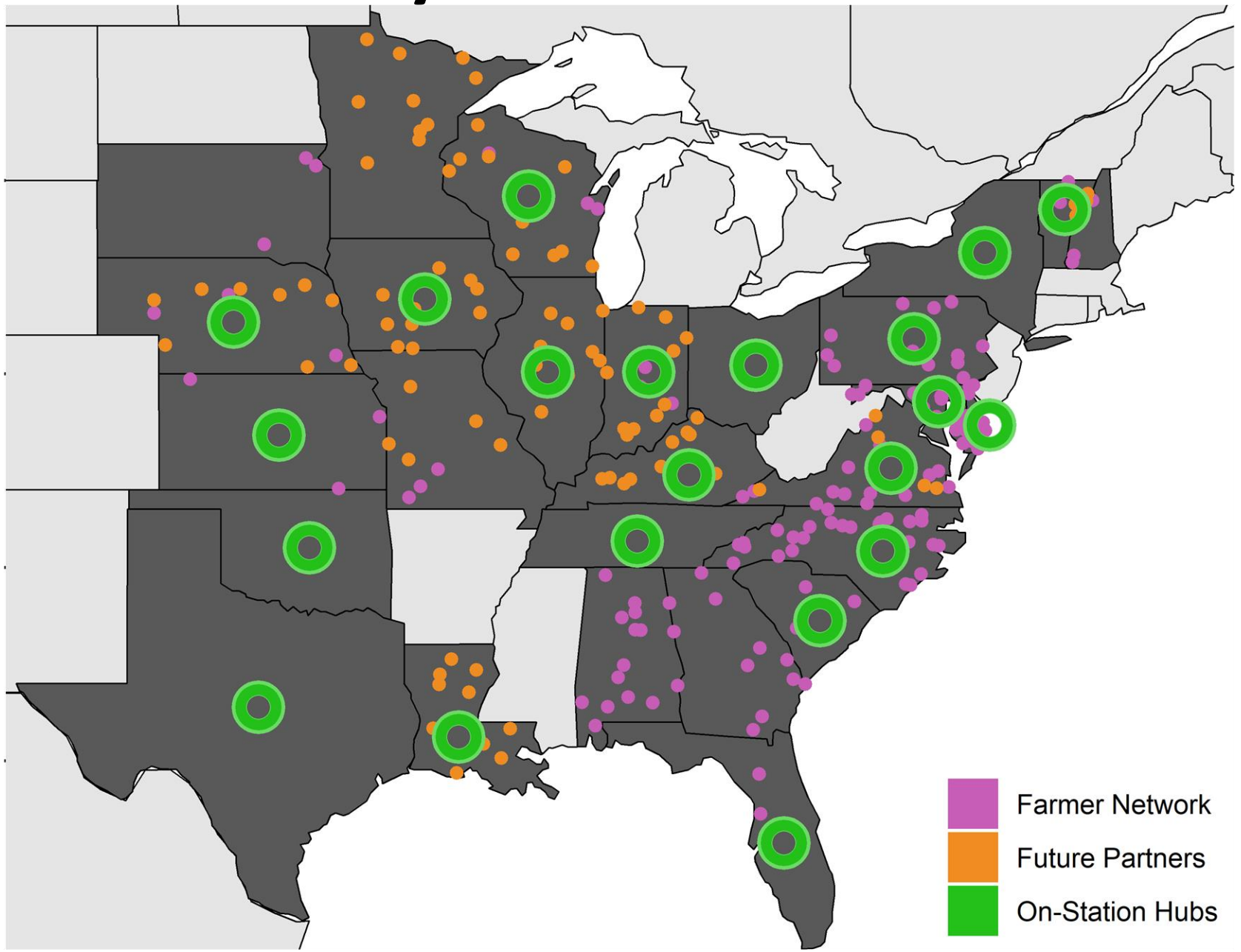


Coordinated USDA-ARS and Land Grant University Network

2020: Committed + Proposed



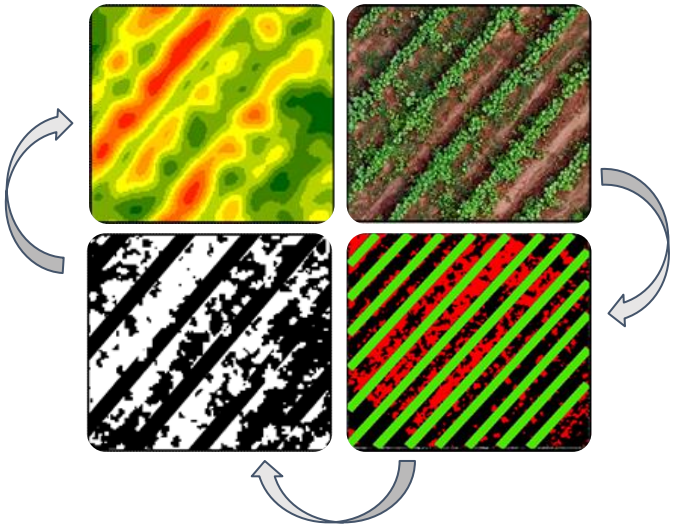
ARS and University On-Farm and On-Station Network



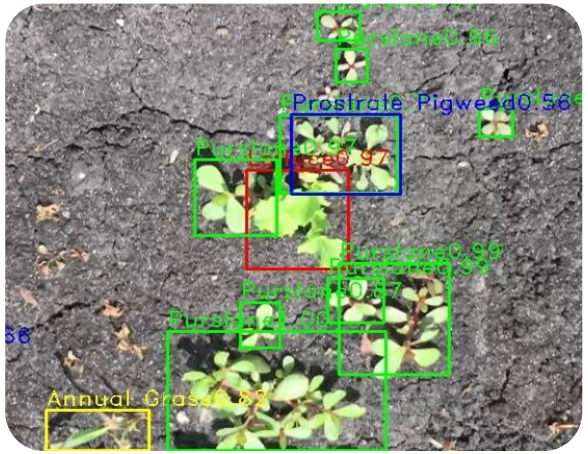
Weed Detection, Mapping and Management

Dr. Muthu Bagavathiannan

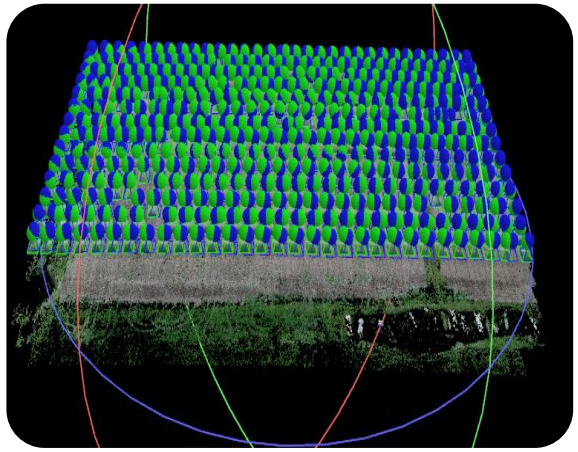
Spray drones and autonomous vehicles



Field mapping of weed infestations



Deep learning



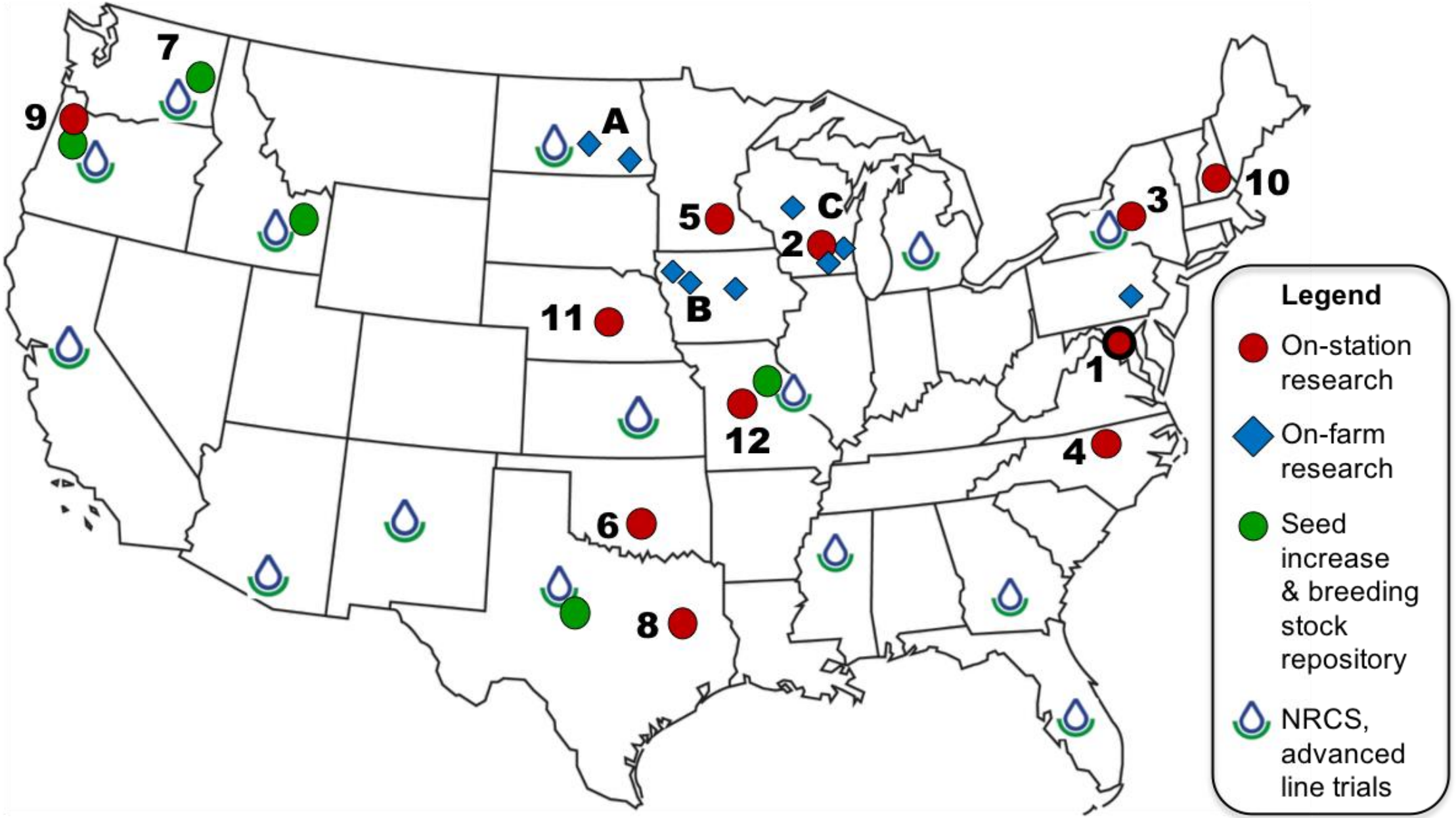
High resolution image acquisition

Herbicide spray using drones

Dr. Muthu Bagavathiannan

TEXAS A&M AGRILIFE RESEARCH

National Cover Crop Breeding Network



Cereal rye breeding (allelopathy)

Precision Sustainable Agriculture

Acknowledgements

Questions?

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NO SEEDS. NO WEEDS.