FOTC 2015 Fertilizer Outlook & Technology Conference

# Rob Zemenchik

**Global Marketing Manager**
**Advanced Farming Systems, Case IH**

# Soil Health and Farm Equipment Technology

The Fertilizer Institute
Nourish, Replenish, Grow

Fertilizer Industry Round Table

# Fertilizer Industry Round Table

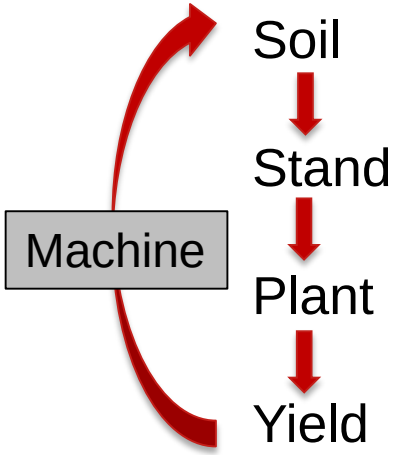
## How Technology is Impacting Soil Health

- An Equipment Industry Perspective

**Dr. Rob Zemenchik**
Case IH – Nov 12, 2015 – Jacksonville, FL USA

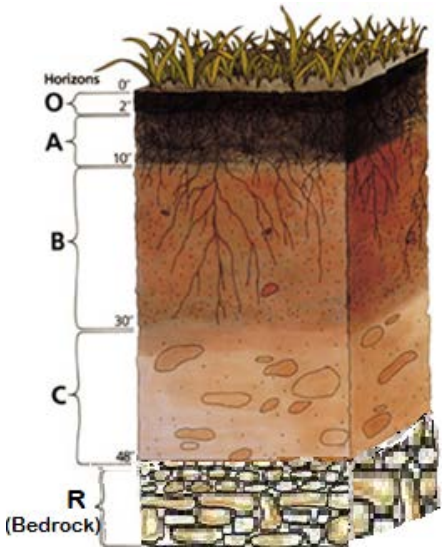
# Soil Health and Equipment Technology

Customer delivery systems for the soil-crop ecosystem




# Soil Quality and Soil Health Definitions.

USDA National Soil Tilth Lab.




***Soil Quality, Definition V 1.0:***

"The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation"

- (SSSAJ. Vol 61: 4-10., Karlen et al., **1997**).

***Soil Health, Definition V 2.0:*** *Latent -> dynamic*

"Soil health, also referred to as soil quality, is defined as the continued capacity of soil to **function** as a vital living ecosystem that sustains plants, animals, and humans."

- (USDA NSTL, **2015**).

- "Regulating water, sustaining plant and animal life, filtering and buffering potential pollutants, cycling nutrients, physical stability and support."

"Soil is an ecosystem that can be managed to provide nutrients for plant growth, absorb and hold rainwater for use during dryer periods, filter and buffer potential pollutants from leaving our fields, serve as a firm foundation for agricultural activities, and provide habitat for soil microbes to flourish and diversify to keep the ecosystem running smoothly."

# Soil Health Assessment

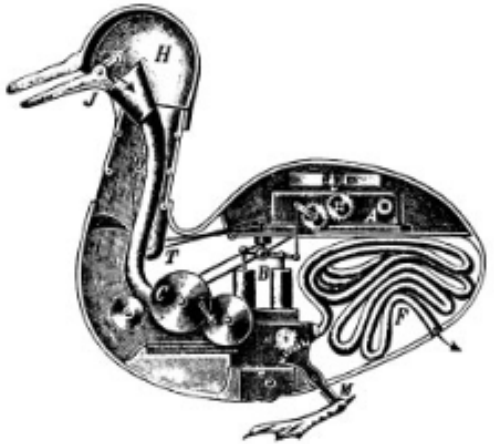
Cannot be measured directly. Rely on indicators.

- **Soil organic matter** => nutrient retention; soil fertility; soil structure; soil stability; and soil erosion
- **Physical**: **bulk density, infiltration, soil structure and macropores, soil depth, and water holding capacity** => retention and transport of water and nutrients; habitat for soil microbes; estimate of crop productivity potential; compaction, plow pan, water movement; porosity; and workability
- **Chemical**: **electrical conductivity, reactive carbon, soil nitrate, soil pH, and extractable phosphorus and potassium** => biological and chemical activity thresholds; plant and microbial activity thresholds; and plant available nutrients and potential for N and P loss
- **Biological**: **earthworms, microbial biomass C and N, particulate organic matter, potentially mineralizable N, soil enzymes, soil respiration, and total organic carbon** => microbial catalytic potential and repository for C and N; soil productivity and N supplying potential; and microbial activity measure

Reductionist approach

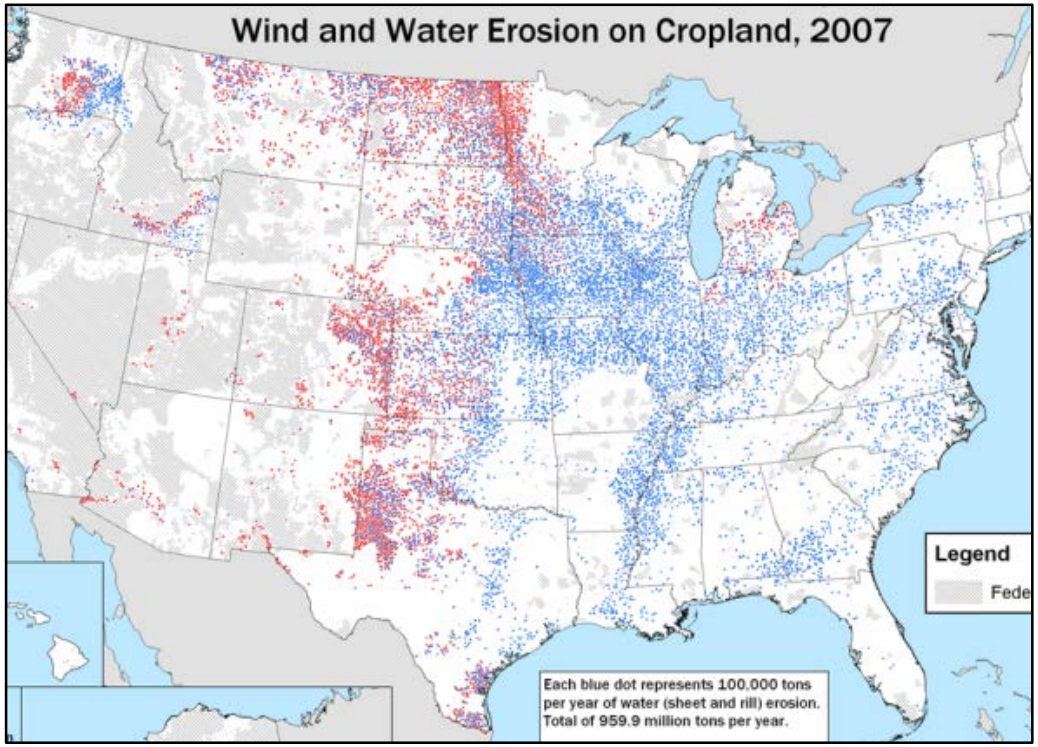
- Risk in overlooking “epiphenomonae” – big picture

What’s Missing???



# U.S. Soil Erosion. Continues to jeopardize soil health

Challenging the concept of “T” – a depletion schedule for topsoil.




Unchecked soil erosion, Providence Canyon, GA

- Current real rate of T = 0.5 t/ac, not 2-5 t/ac
- Current rate of erosion >5 t/ac

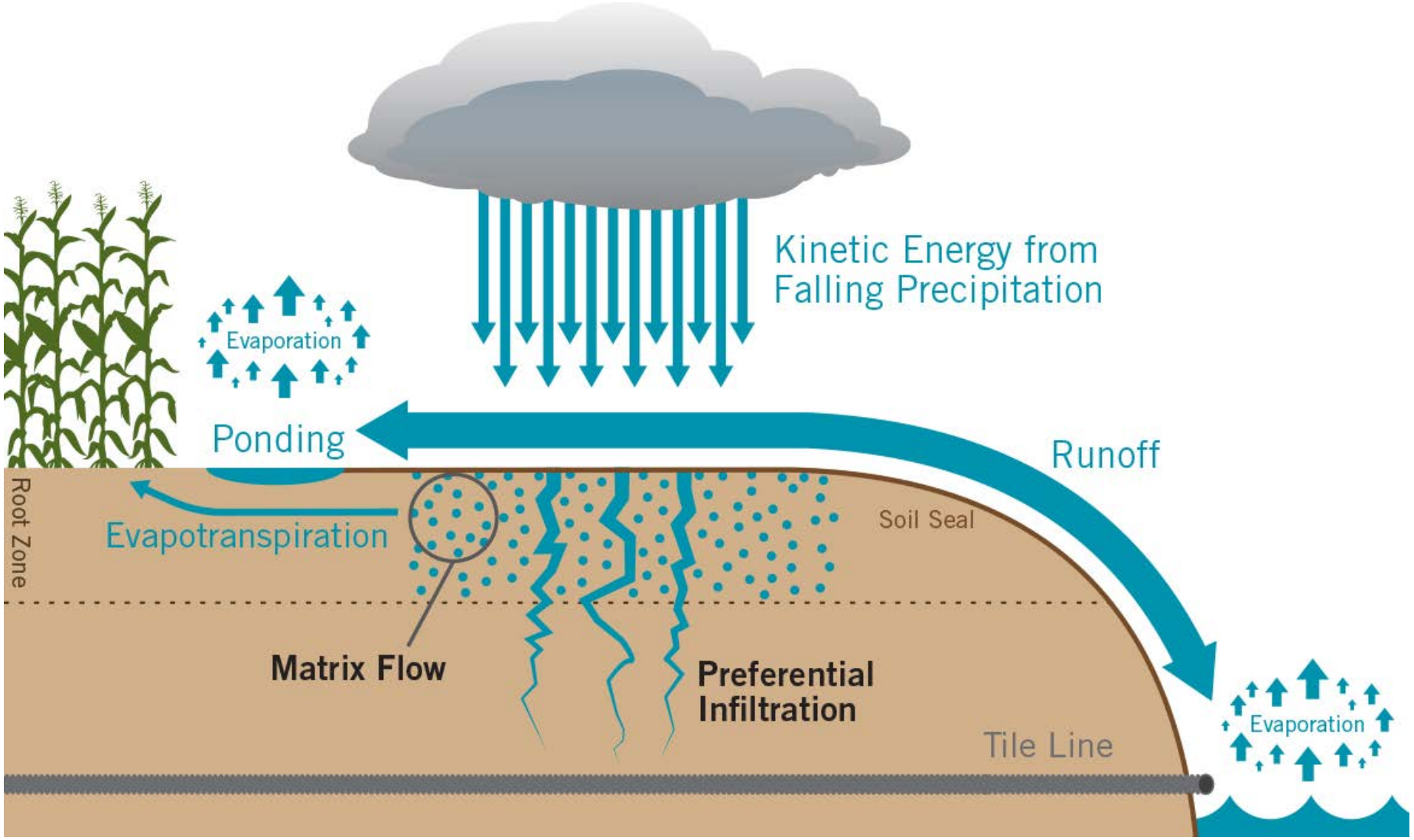
  Dr. R. Cruise, Iowa State Univ.

50% of IA topsoil has been lost this century
At current rates, “Topsoil will be gone by 2075”

- WI = lost acre furrow slice by WW2 – F.H. King
- IA = 15M tons of soil lost in 2014

USLE, RUSLE, WEQ, WEPS

# Runoff and the soil hydrosphere



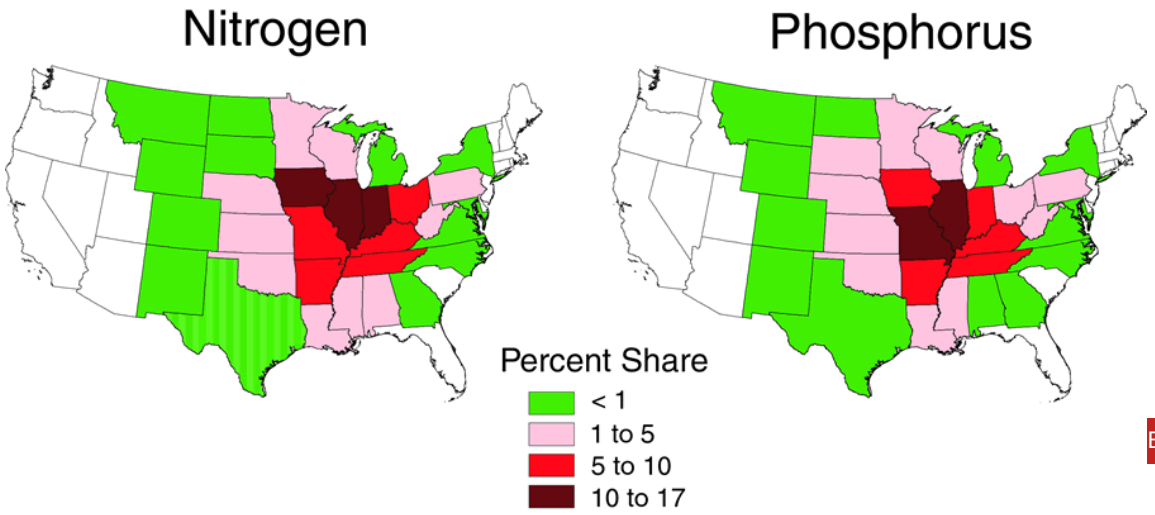
# Estimated N + P Source Loads by State

Spatially Referenced Regression On Watershed Attributes (SPARROW). 425 stations.

Gulf of Mexico

- Dead zone now the size of CT
- appx 5,500 sq miles, 3.5M ac

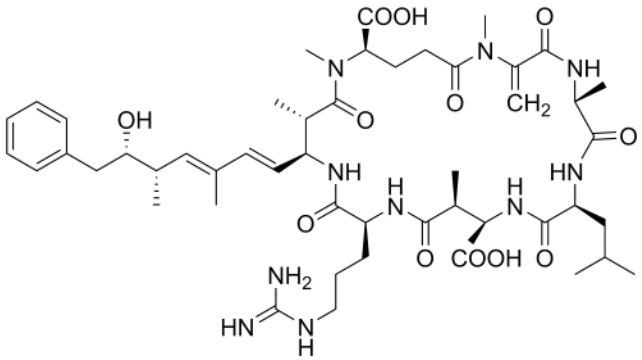
**BAP = DP + PP**
**Effective depth of interaction (EDI)**




# Algae blooms in Lake Erie, 2014

400,000 people had no safe drinking water Aug 2014, National Guard called out.

- 70 people hospitalized
- Microcystin levels 100% above WHO limit



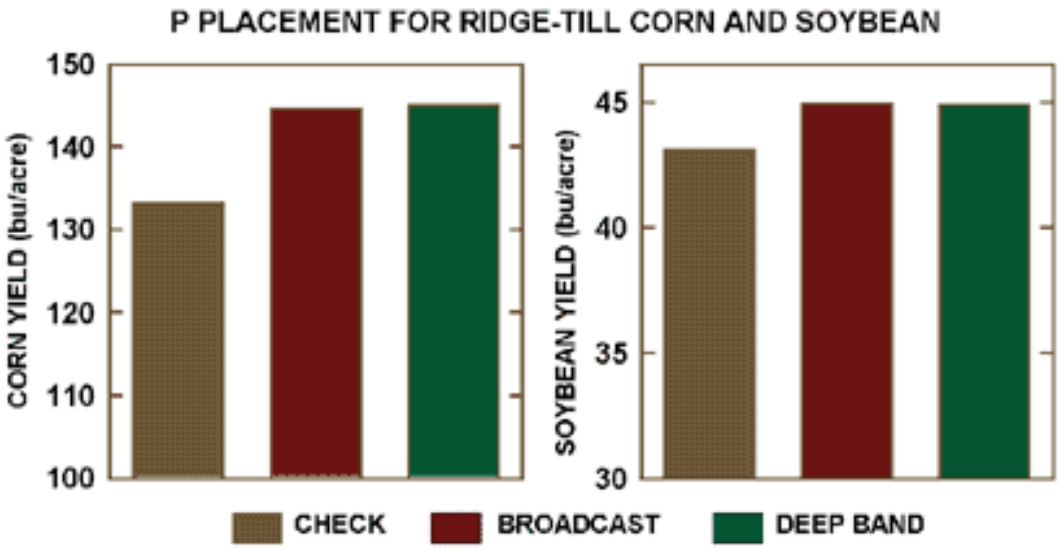

: Class of toxins produced by certain freshwater Cyanobacteria, primarily Microcystins. Toxic to the liver.

# What can agriculture do now? 4R Delivery Systems

c. 1994

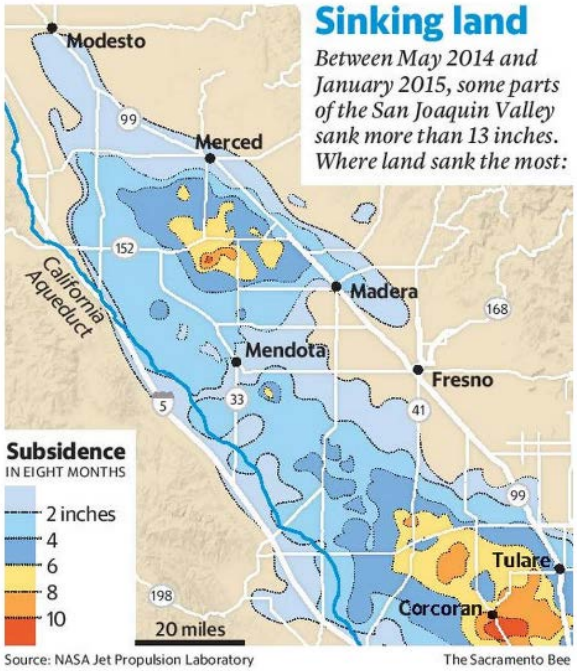

- Solutions that build on the 4R concept as best practices
- Right rate
- Right time
- Right placement
- Right product

85-90% field efficiency required

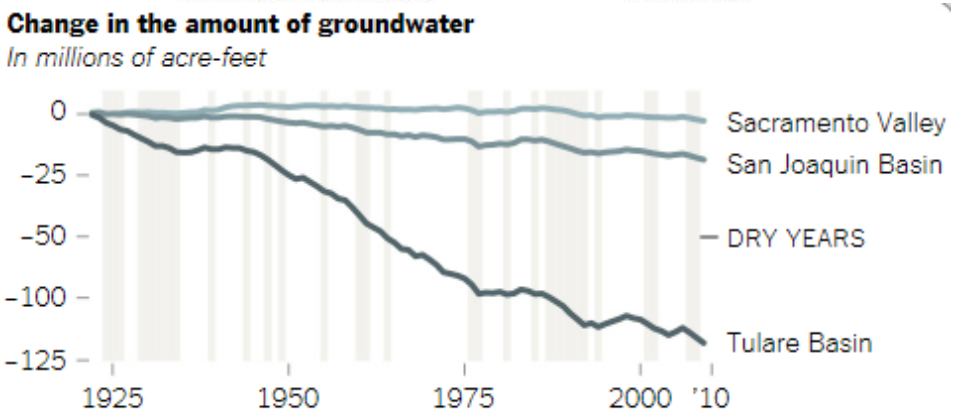


# Weather Extremes Compound Soil Health Risks.

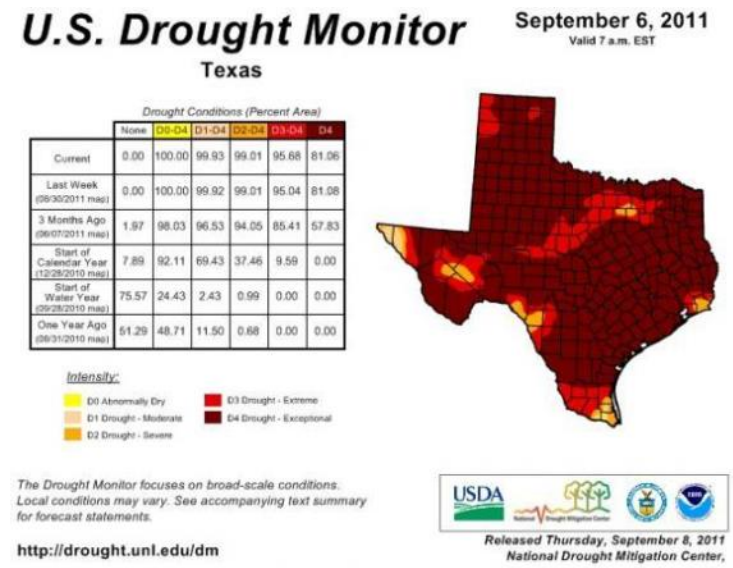
California drought = subsidence 2”/mo, South Carolina floods, New Jersey hurricanes








Sources: California Department of Water Resources; NASA; U.S. Geological Survey; Public Pol



# California desertification


(Source: Fresno, CA *The Guardian*)

# Soil Health: Soil Health Risks.

Soil ecosystems out of balance present risks, do not “run smoothly” or sustain man, plants, animals.

Glyphosate Resistant Giant Ragweed (*Ambrosia trifida*) infesting Roundup Ready Corn. Photo: Dr. Bill Johnson

# Palmer Amaranth Resistance

*Amaranthus Palmeri*: Highly resistant, mobile

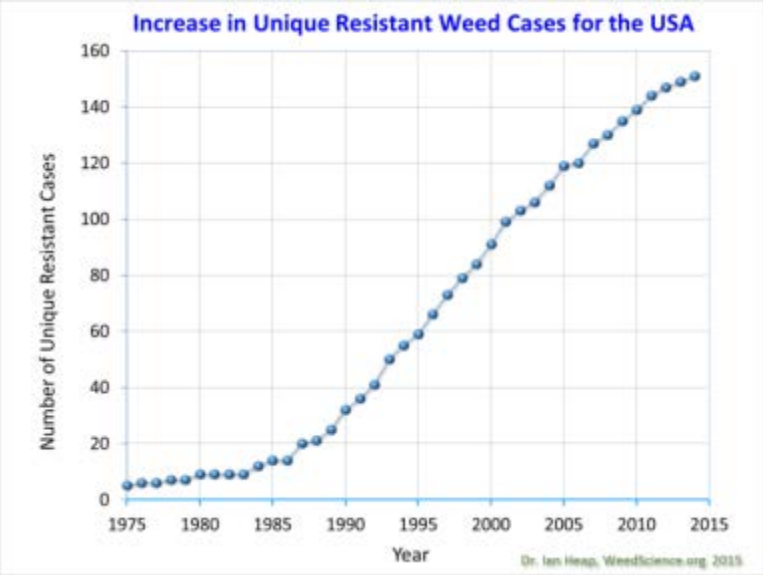
- Male or female
- 7-10’ tall
- Spread by seed or pollin (>164’)
- > 1,000,000 viable seeds by female plants
- $75-100/ac in GA alone, $>1B in last 10 years.

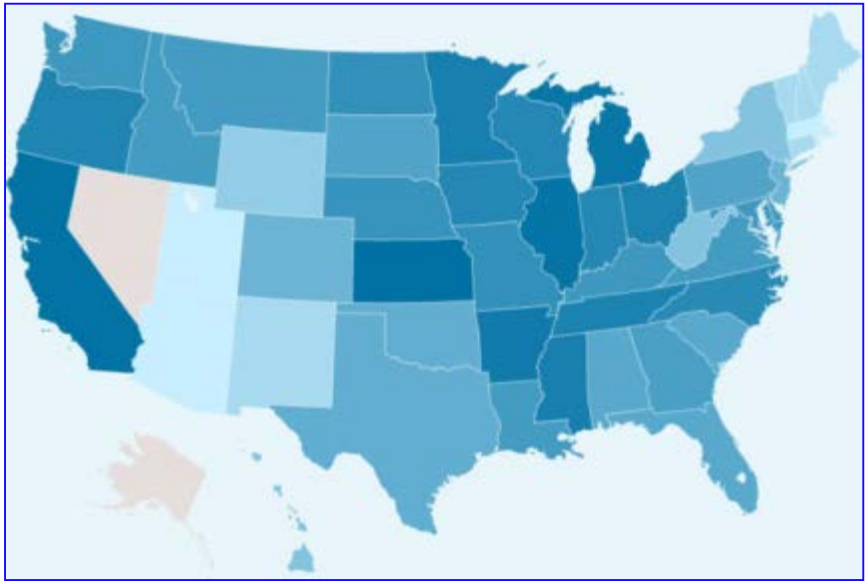
**32 States: confirmed resistance**

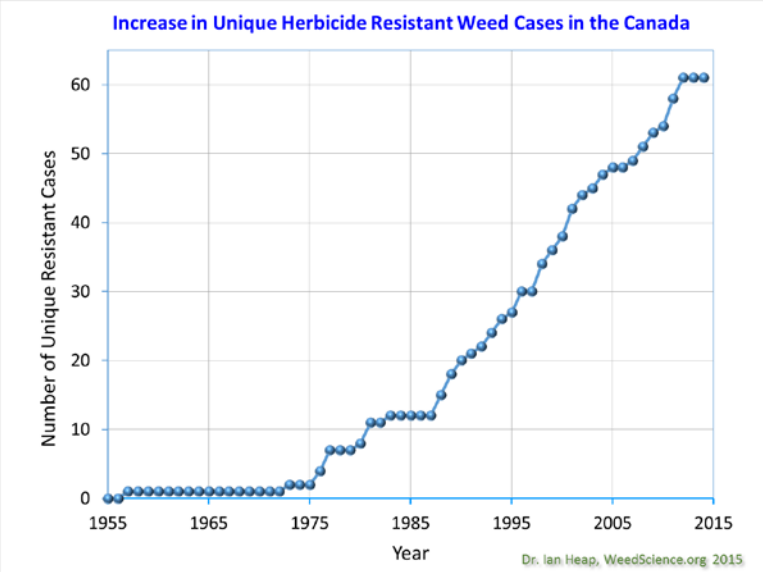
2005 - United States (Georgia)
2005 - United States (North Carolina)
2006 - United States (Arkansas)
2006 - United States (South Carolina)
2006 - United States (Tennessee)
2007 - United States (New Mexico)
2008 - United States (Alabama)
2008 - United States (Georgia) *Multiple - 2 SOA's
2008 - United States (Mississippi) *Multiple - 2 SOA's
2008 - United States (Missouri)
2009 - United States (Tennessee) *Multiple - 2 SOA's
2010 - United States (Georgia) *Multiple - 3 SOA's
2010 - United States (Illinois)
2010 - United States (Kentucky)
2010 - United States (Louisiana)
2010 - United States (Ohio)
2010 - United States (South Carolina) *Multiple - 2 SOA's
2011 - United States (Kansas)
2011 - United States (Michigan)
2011 - United States (Texas)
2011 - United States (Virginia)
2012 - United States (Arizona) *Multiple - 2 SOA's
2012 - United States (Delaware)
2012 - United States (Indiana)
2013 - United States (Florida)
2013 - United States (Florida) *Multiple - 2 SOA's
2013 - United States (Illinois) *Multiple - 2 SOA's
2013 - United States (Pennsylvania)
2013 - United States (Wisconsin)
2014 - United States (Delaware) *Multiple - 2 SOA's
2014 - United States (Maryland) *Multiple - 2 SOA's
2014 - United States (New Jersey)

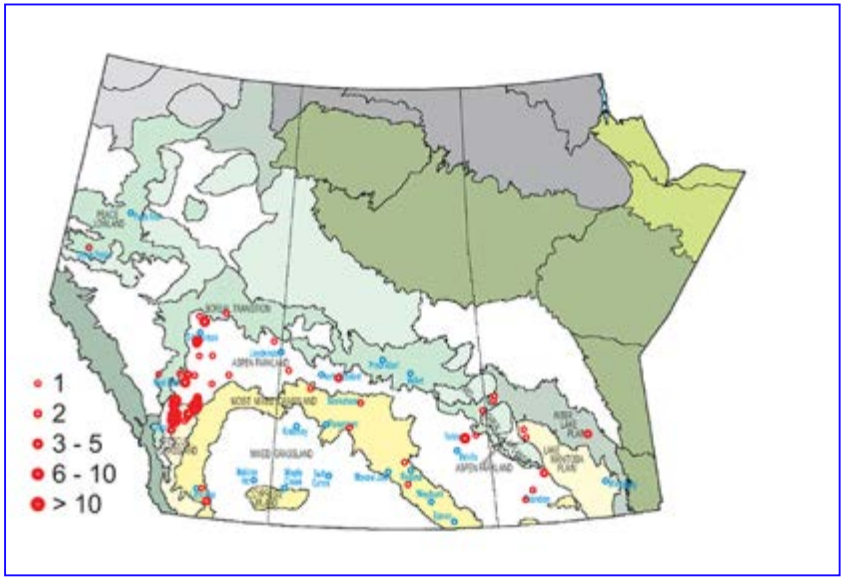
# U.S. and Canada Weed Resistance

Does the Soil Health Assessment account for resistance?



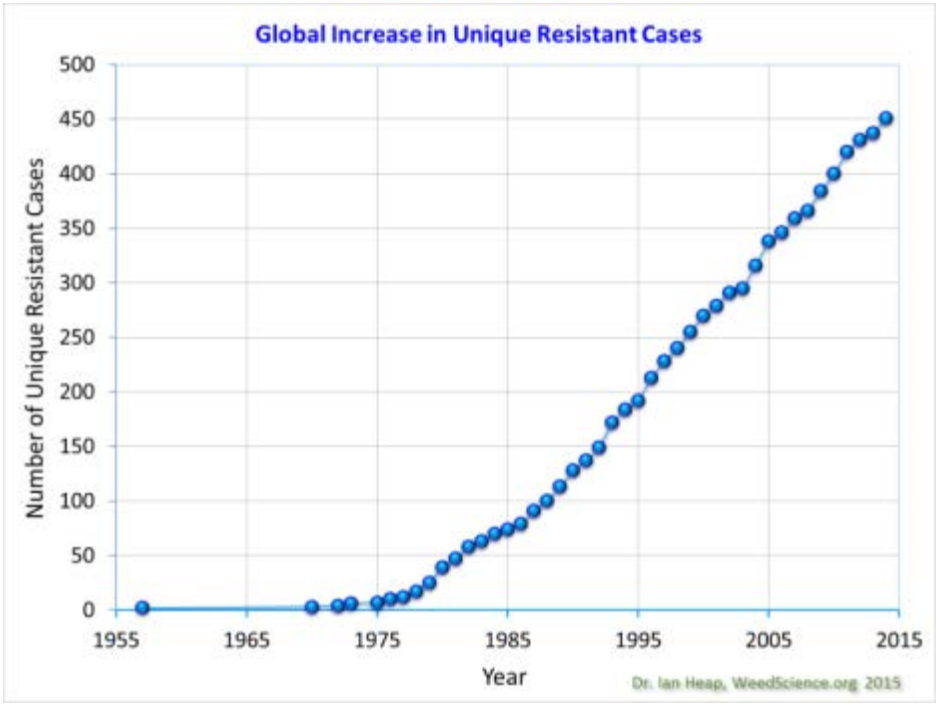



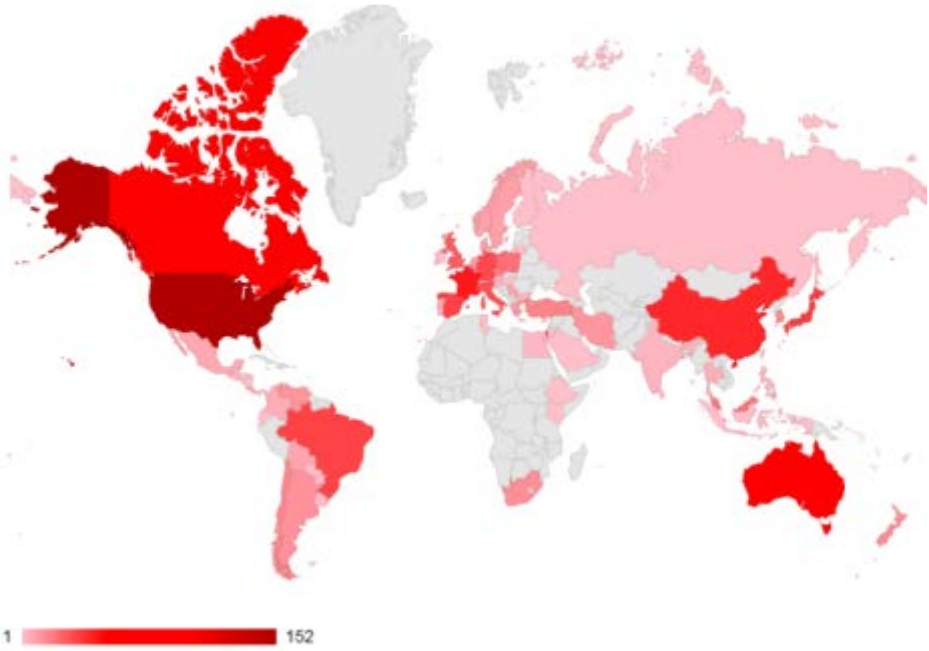


# Worldwide Global Weed Resistance

Prolonged use of same tools creating widespread resistance issues



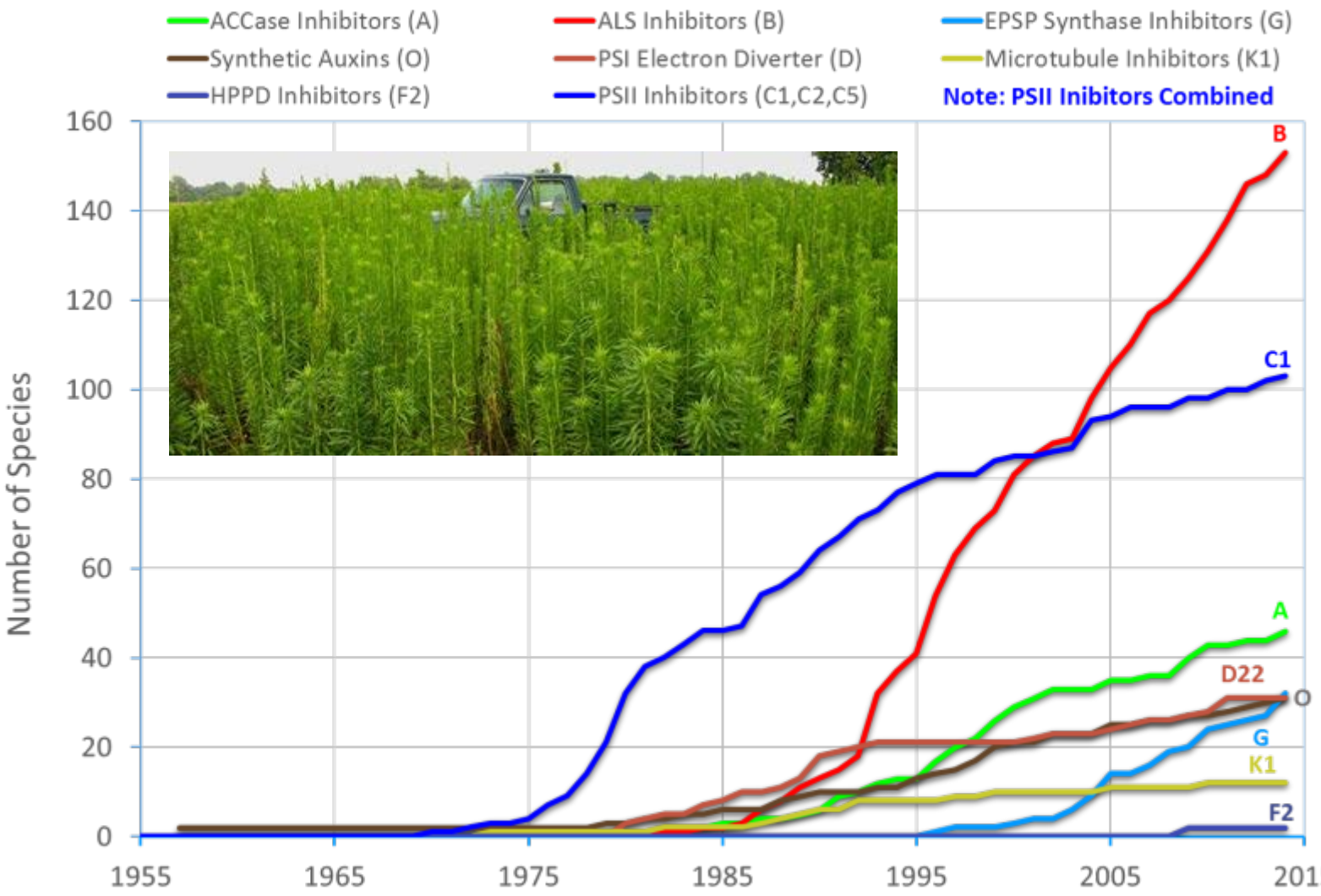




Is soil health getting better or worse in production agroecosystems?

# Resistance by Mode of Action

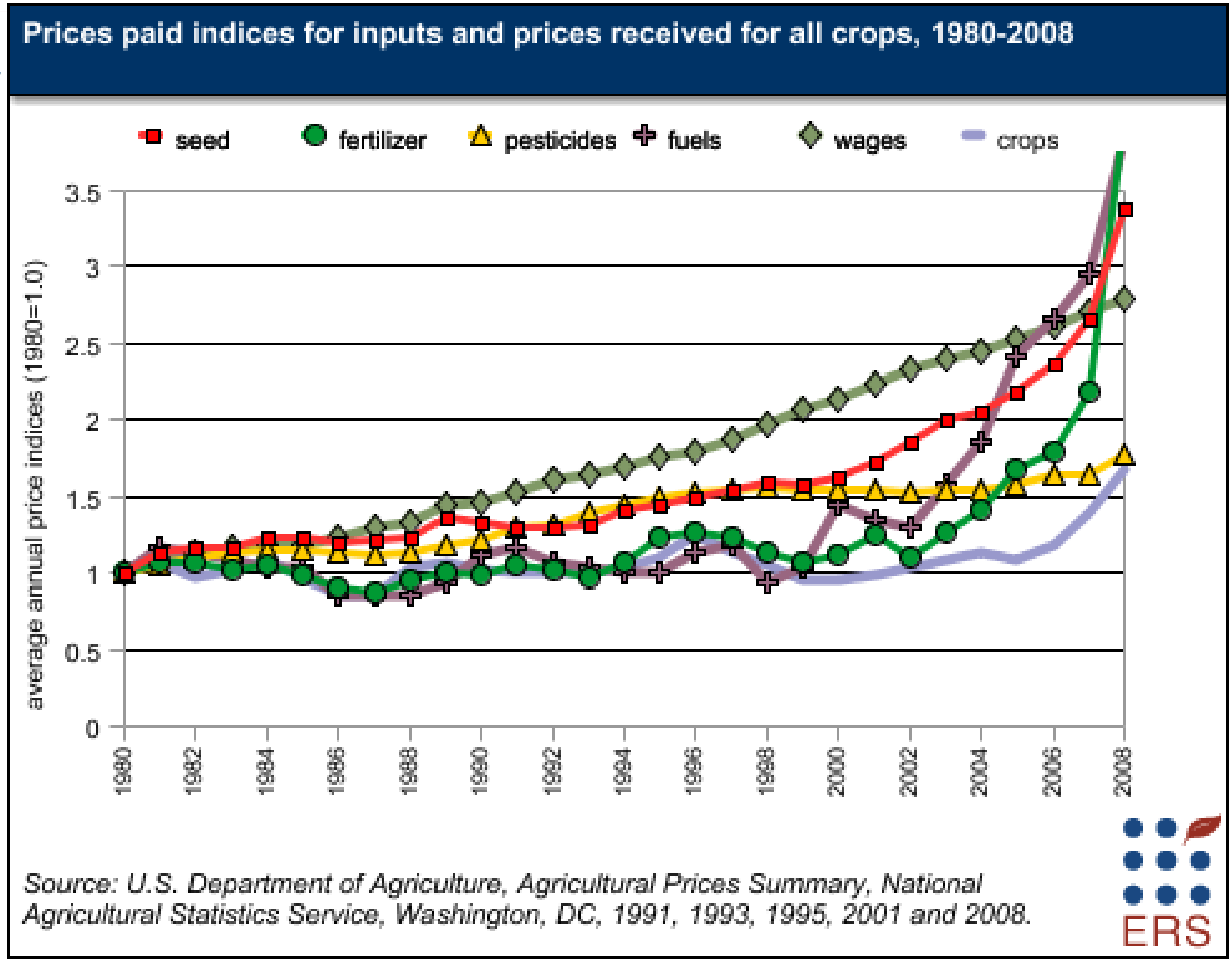
Rotating modes of action

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



# U.S. Crop Input Inflation

Non-pesticide inflation, relative affordability of pesticides.



# Herbicide Persistence and Toxicity

Toxicity, persistence in soil, leaching potential

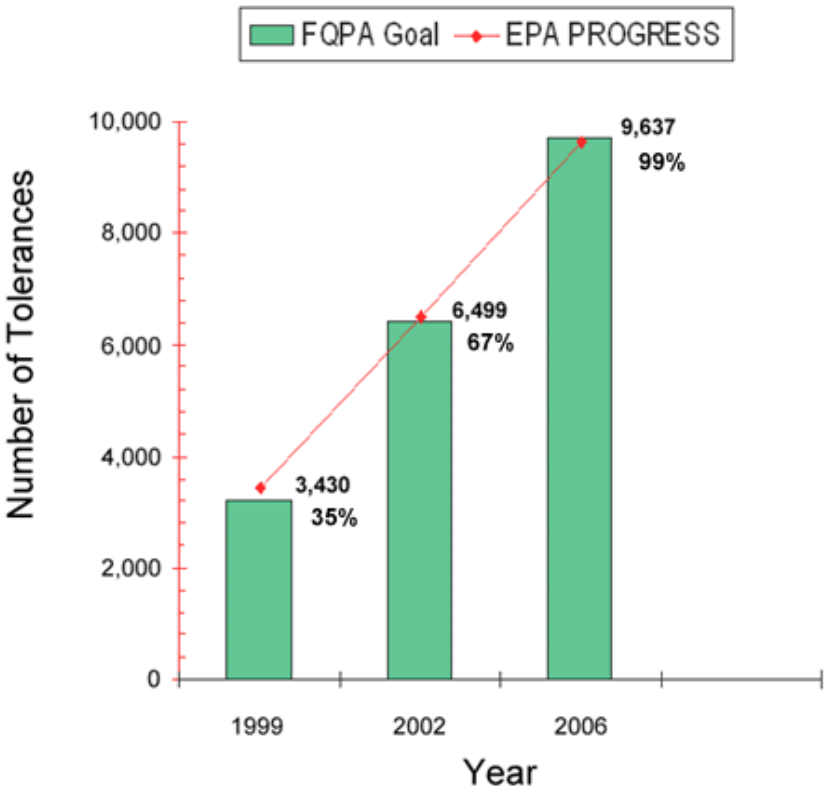
| Common Name | Trade Name | Oral LD50 (1) | Dermal LD50 (1) | EPA Toxicity (2) | Toxicity to Beneficials (3) | Persistance in Soil (4) | Leaching Potential (4) | EIQ (5) |
|---|---|---|---|---|---|---|---|---|
| Bentazon | Basagran | 1100 | >2500 | III | 15 | Low | Small | 20.3 |
| Carfentrazone | Aim | 5143 | >4000 | IV | 23.6 | Low | Small | 21.5 |
| Clethodim | Prism/Select | 2920 | >5000 | II | 15 | Low | Small | 17 |
| Dichlobenil | Casoron | 3160 | 1350 | NDA | 19.35 | NDA | Small[eiq] | 20.8 |
| Diruron | Karmex | >5000 | >5000 | III | 9 | High | Med | 20.5 |
| Fluazifop | Fusilade | 2450 | >2420 | IV | 15 | Low | Small | 17 |
| Glufosinate | Rely | 2000 | >2000 | NDA | 51 | NDA | High[eiq] | 28.3 |
| Glyphosate | Roundup | 5600 | >5000 | II | 15 | Mod | Low | 15.3 |
| Hexazinone | velpar | 1690 | >5278 | I | 15 | High | Med | 18 |
| Isoxaben | Gallery | >10000 | >2000 | NDA | NDA | NDA | NDA | NDA |
| Napropamide | Devrinol | >5000 | >4640 | III | 10.7 | Mod | Med | 18.8 |
| Norflurazon | Solicam | >8000 | >20000 | NDA | 17 | NDA | High[eiq] | 12.6 |
| Oryzalin | Surflan | >10000 | >2000 | IV | 9.3 | Mod | Med | 19.4 |
| Paraquat | Gramoxone | 150 | 236 | I | 19.95 | High | Small | 31 |
| princep | Simazine | >5000 | >3100 | I | 14.2 | Mod | Small | 15.7 |
| Pronamide | Kerb | 8350 | >3160 | I | 51 | Mod | Small | 36 |
| Sethoxydim | Poast | 3200 | >5000 | I | 14.2 | Mod | Small | 15.7 |
| Terbacil | Sinbar | >5000 | >5000 | I | 12.5 | High | Large | 16.8 |

This table is a compilation of information from many sources.

(1) LD50 values taken from "The Pesticide Book" by George Ware and "Pesticide Information Profiles", EXTOXNET.
(2) Toxicity Rating is based on acute oral LD50 values ("I" is most toxic; "IV" is least toxic).
(3) Relative hazard to applicators is based on dermal exposure (source EB 1491).
(4) Beneficial toxicity based on Cornell EIQ (higher numbers equate to greater likelihood for killing arthropod natural enemies)
(5) Leaching Potential rating from Washington State Water Quality Guide and "Pesticide Information Profiles", EXTOXNET.
(6) Groundwater leaching potential based on Cornell EIQ (1:small; 5:large).
(7) Comments regarding groundwater based on "Pesticide Information Profiles", EXTOXNET.

# Food Quality Protection Act, 1996

Required reassessment of tolerances for all residues by 2006




By 2006, EPA had cancelled 4,400 pesticides from a universe of 17,592. Today, there are over 1,055 active ingredients registered as pesticides (USDA).

USDA: Before allowing the use of a pesticide on food crops, EPA sets a tolerance, or maximum residue limit, which is the amount of pesticide residue allowed to remain in or on each treated food commodity. The tolerance is the residue level that triggers enforcement actions. If in excess, seizure results

To make this finding, EPA considers:

1. the toxicity of the pesticide and its break-down products
2. how much of the pesticide is applied and how often
3. how much of the pesticide (i.e., the residue) remains in or on food by the time it is marketed and prepared

**No standard for the soil has been set.**

**(Toxicity x Persistence) = (T x P) / t**

**t**

where T = EPA toxicity class (I, II, III, IV…) = 4, 3, 2, 1, respectively)
where P = EPA persistence class (H, M, L = 3, 2, 1 respectively)
where t = total calendar years since each a.i. application

The higher the demerit score, the lower the implied soil health

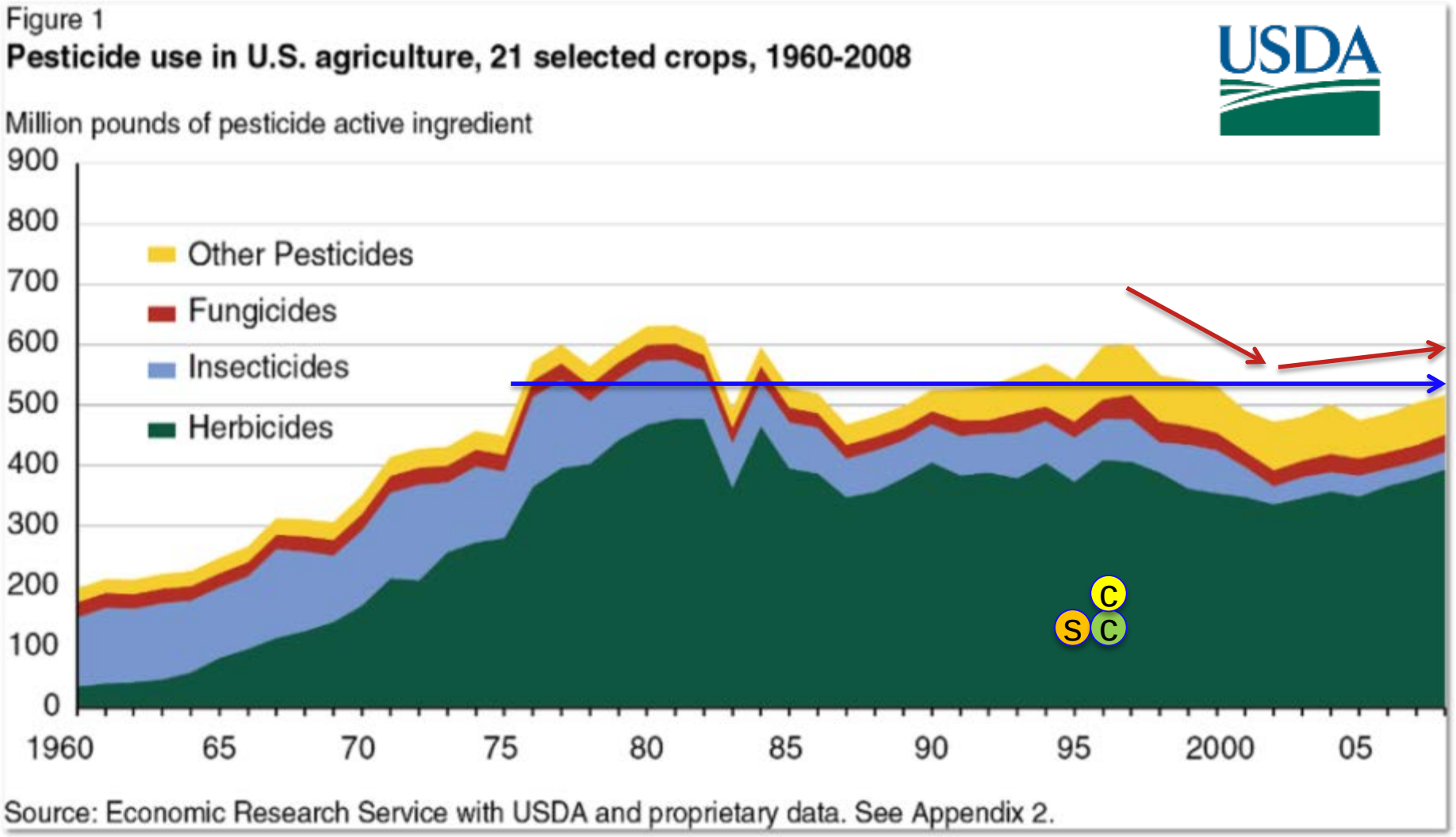
# LD50 Paradigm Outdated

$t_{(yr)}$ to kill 50% of the test group (1927)

| Routes of Exposure | Toxicity Cat. I | Toxicity Cat. II | Toxicity Cat. III | Toxicity Cat. IV |
|---|---|---|---|---|
| Oral $LD_{50}$ | Up to and including 50 mg/kg | 50–500 mg/kg | 500–5,000 mg/kg | >5,000 mg/kg |
| Inhalation $LC_{50}$ | Up to and including 0.2 mg/l | 0.2–2 mg/l | 2–20 mg/l | >20 mg/l |
| Dermal $LD_{50}$ | Up to and including 200 mg/kg | 200–2,000 mg/kg | 2,000–20,000 mg/kg | >20,000 mg/kg |
| Eye Effects | Corrosive corneal opacity not reversible within 7 days | Corneal opacity reversible within 7 days; irritation persisting for 7 days | No corneal opacity; irritation reversible within 7 days | No irritation |
| Skin Effects | Corrosive | Severe irritation at 72 hours | Moderate irritation at 72 hours | Mild or slight irritation at 72 hours |
| Signal Word | DANGER<br>POISON | WARNING | CAUTION | CAUTION |

# U.S. Pesticide Application Rates

What has been the net effect of transgenic crops?



# New Tools: RNA-Interference Based Insecticides

Gene silencing technique, “quelling”, “knockout.” Small, post-transcriptional RNA’s that bind to mRNA’s that promote enzyme cleavage and suppress gene expression

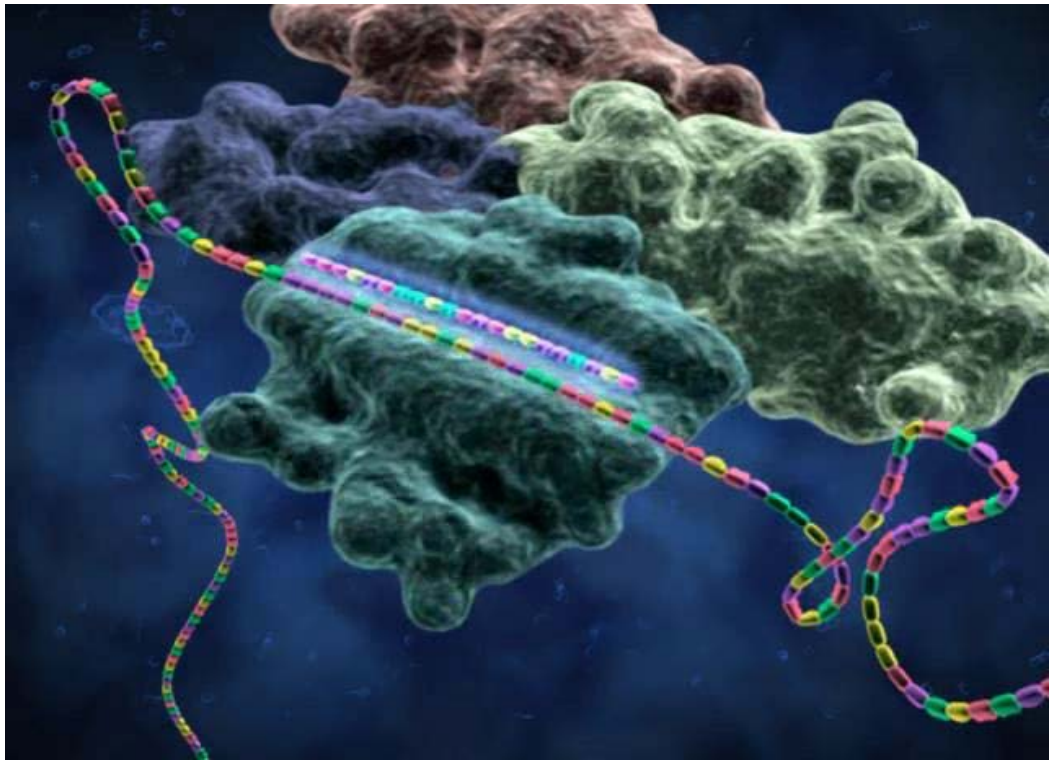


Photo credit: gmoevidence.com

## Benefits:

- Can be imparted to existing genetics
- Delayed onset of *Cry* resistance
- Selectively lethal to target organisms
- Shown to reduce enzyme translation
- Stops gossypol terpenoids in cotton

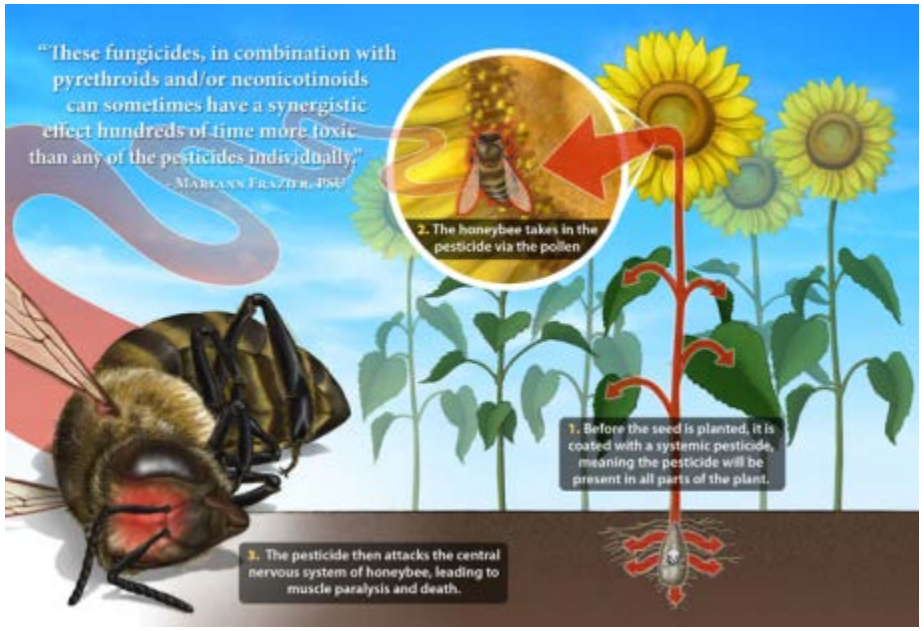
## Risks:

- Off-target gene silencing in target organism
- On-target gene silencing in non-target organisms
- Immune response stimulation
- Saturation of cellular RNA machinery
- Persistence of RNA’s in the soil-water
- Toxicity assessment techniques

What will be the delivery system?

# Honeybees and Neonicotinoids

Planter vacuum modification in 2015. New formulae, less prone to blowing

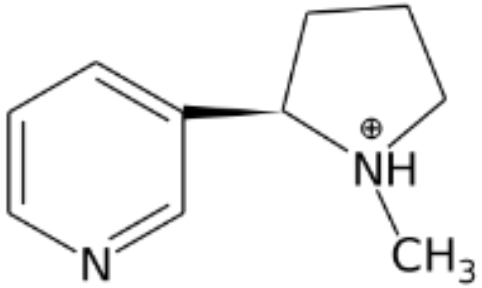



Tony Linka, Illustration


Neonicotinoids persist many years in soil (>6 yrs) and systemically absorbed by succession plants

Planters must be modified for the 2016 crop year

- Non-graphite lubricant
- Downward fan ventilation




| Neonicotinoid | Aerobic half-life in soil |
|---|---|
| acetamiprid | 1-8 days |
| clothianidin | 148-1155 days |
| dinotefuran | 138 days |
| imidicloprid | 40-997 days |
| thiacloprid | 1-27 days |
| thiamethoxam | 25-100 days |

source: EPA

# Next Generation Farm Management Solutions

Efficient Power, Agronomic Design, Advanced Farming Systems,


Scale and Productivity

Flexibility, Prediction, and Control

EFFICIENTPOWER EP
MORE PRODUCTIVITY ▪ LESS FUEL

AGRONOMIC DESIGN

AFS ADVANCED FARMING SYSTEMS

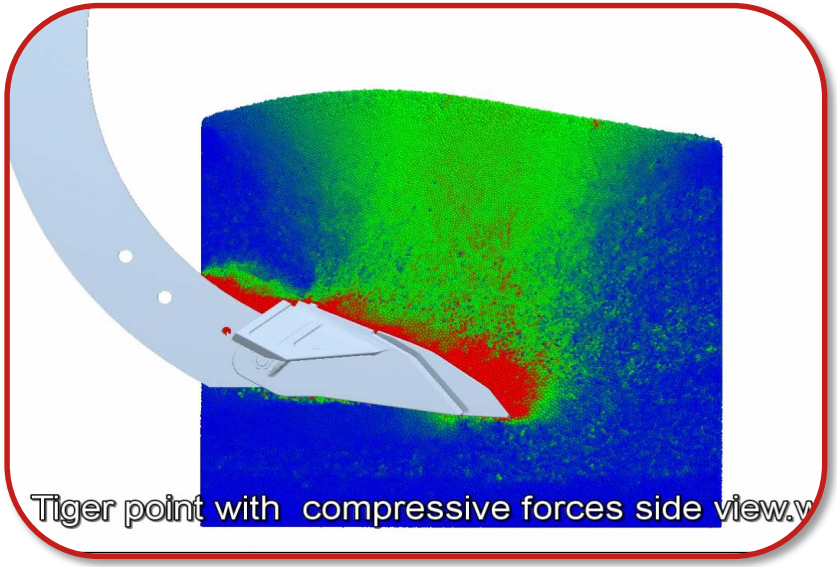
CNH INDUSTRIAL

# Improved Soil Management tools

Next generation ecolo-tiger: 7th-gen 870 in 2009, 8th-gen 975 in 2013.

## Improved Crop Residue Management

- Control, rather than subdue residue cover
- ~20% more cover than prior models
- High residue systems
- Improved residue clearance
- Level output for less Spring tillage
- Reduced sealing and runoff potential

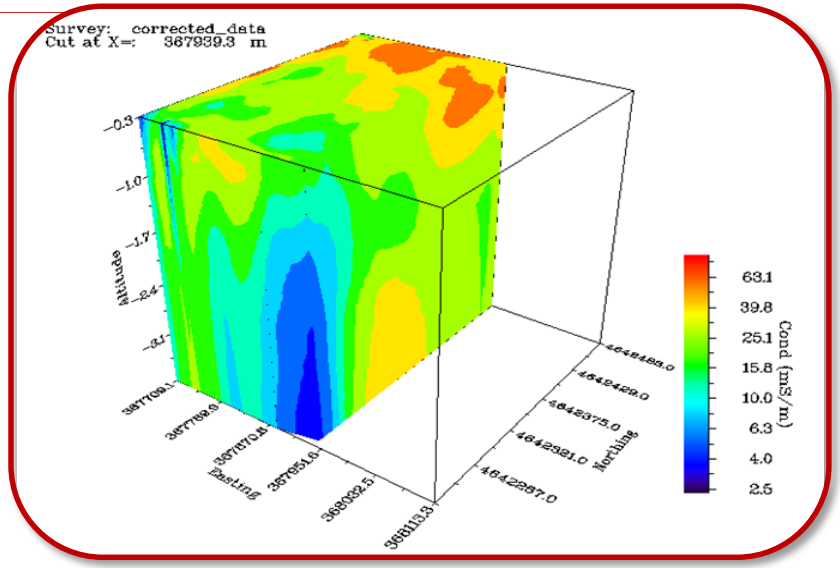



## Soil and draft-efficient tillage points

- Maximize lift dynamics
- Optimize draft efficiency
- Targeted fracture
- Less re-compaction
- Maintain more soil structure
- Improved fuel use

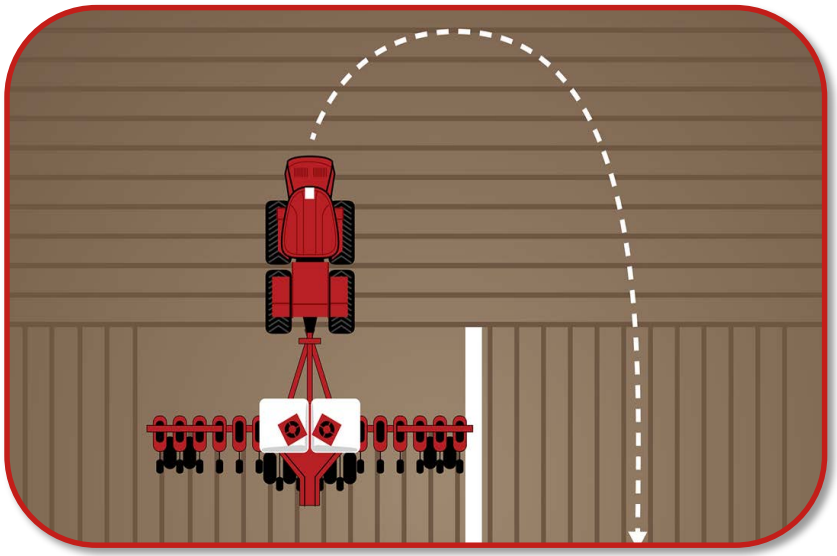
# Improved Soil Analysis and Machine Output

Next generation mapping solutions and dynamic modeling. Machine performance.




## Enhanced soil modeling

- Full root zone to 10’ deep
- Correct historical mismapping (~20%)
- Fertility management
- Multi-hybrid strategies
- VRT rec maps



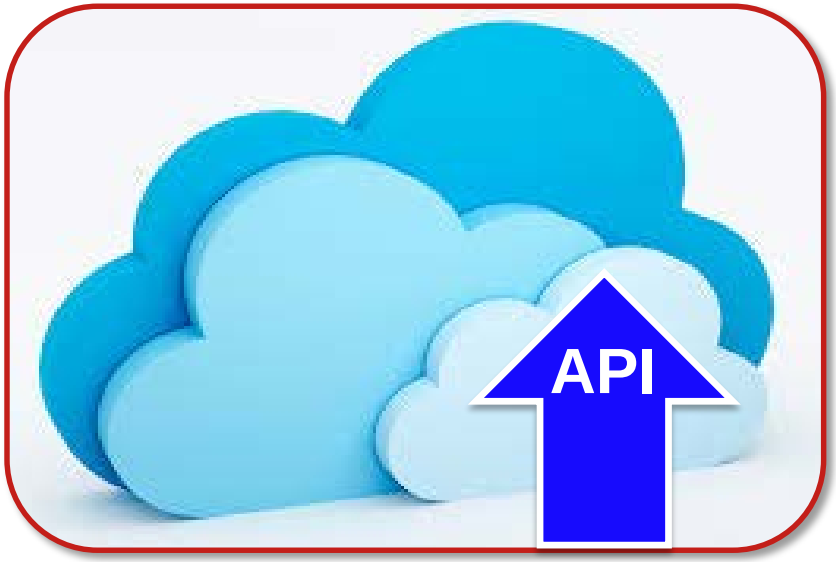
## Automated machine tasks

- Continue to evolve
- End of row functionality
- Eliminate over-application
- Enhance input utilization
- Productivity and profitability

AFS ADVANCED FARMING SYSTEMS

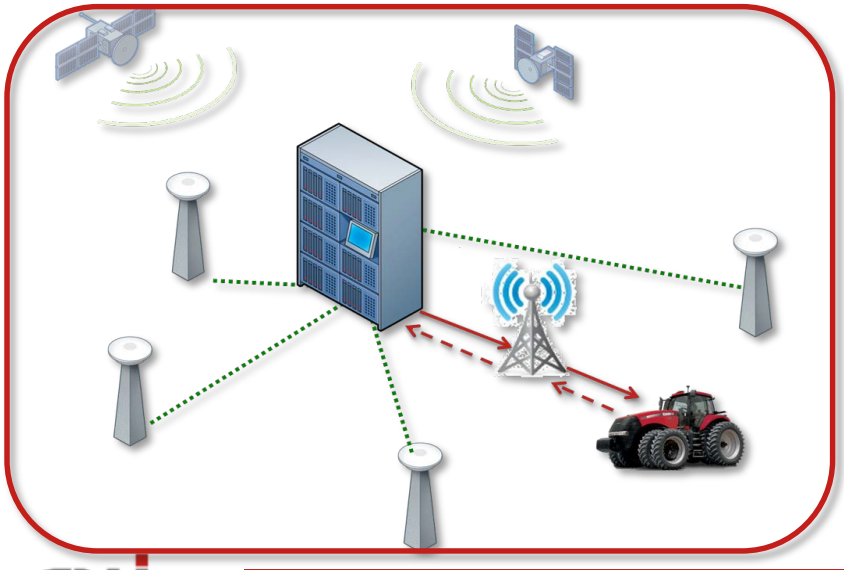
# Next-Gen Data Management and Guidance

Data value analysis and increased guidance adoption




## Application Programming Interfaces

- Data storage and value definition
- Authorized access
- 3rd party interfaces, ease of data flow
- Rec map generation
- Eg. Decision making tools
- Eg. As-applied record keeping
- Eg. Productivity logistics

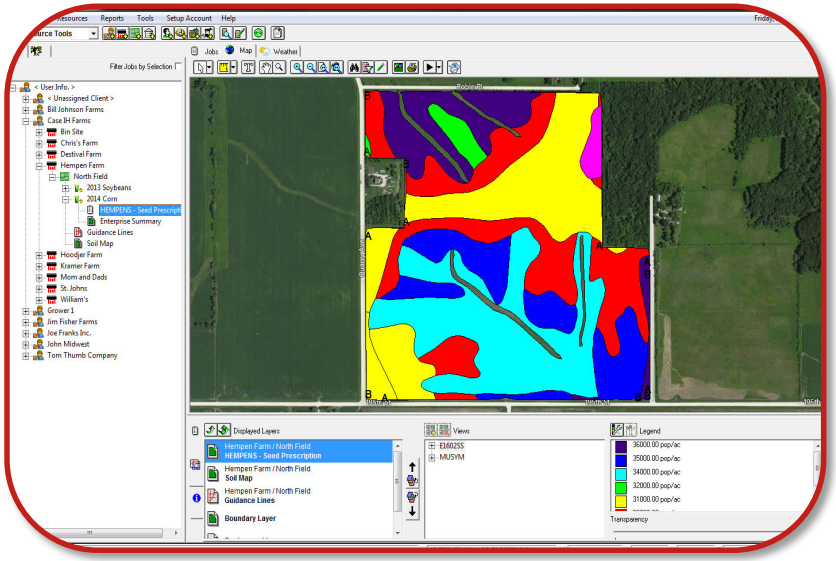


## RTK+ Cellular Network Correction

- Lower cost than 450/900 radio
- NTRIP, no line of sight dependency
- Open architecture: RTCM
- Not point to point
- Disruptive technology

# Mapping Technology

In time, every machine will accept or generate both “rec” and “as-applied maps”



## Automated rec maps

- Inputs spatially matched to field conditions
- Drives efficiencies
- Improves resource allocation
- Reduced risk of adverse outcomes
- Profitability

## Precise Section Control

- Automated row shutoff
- Reduced overlap, over-application
- Reduced input costs
- Crop protection and harvest efficiencies

# Seeding Technology

AccuSection, Variable Rate, Turn Compensation, small seed singulation

## AccuSection Control

- Independent seed meter sections
- Reduced overlap
- Turn compensation
- Fertilizer use efficiency
- App based ECU
- Transferable software

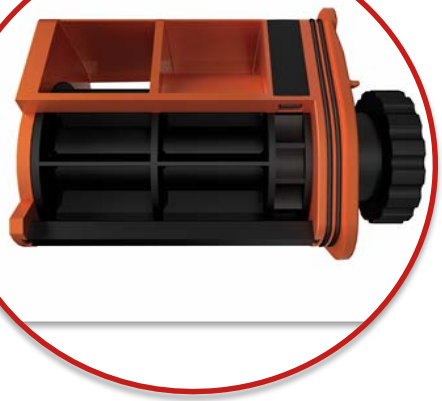
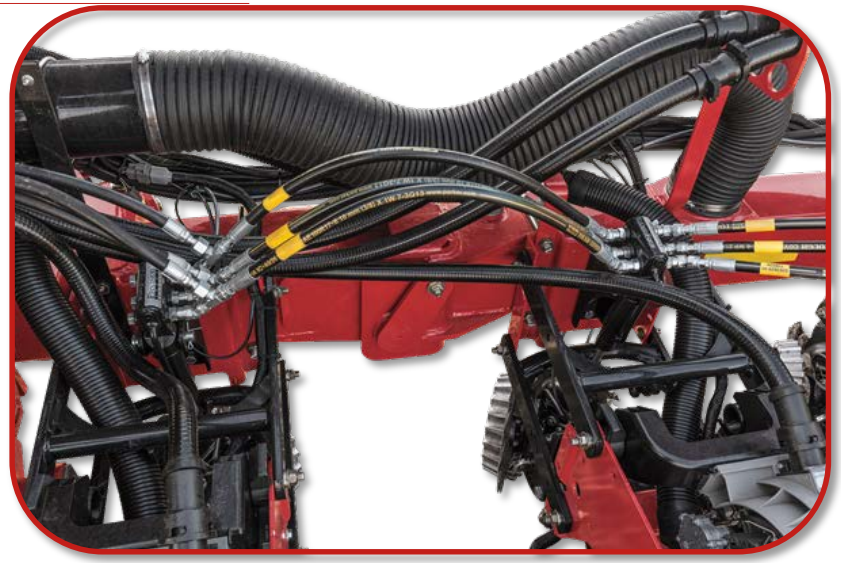


Photo credit: Soytech

# “Live” Planter Technology With Real-Time Mapping.

Analyze planter row unit performance, export/stream and map data.



## Automated data mapping

- Downpressure sensing and mapping
- Seed rates matched to soil types
- Automatic instead of manual adjustments
- As-applied maps in near real time
- Row-to-row independence and control

AFS ADVANCED FARMING SYSTEMS

In-cab tablet showing real-time map

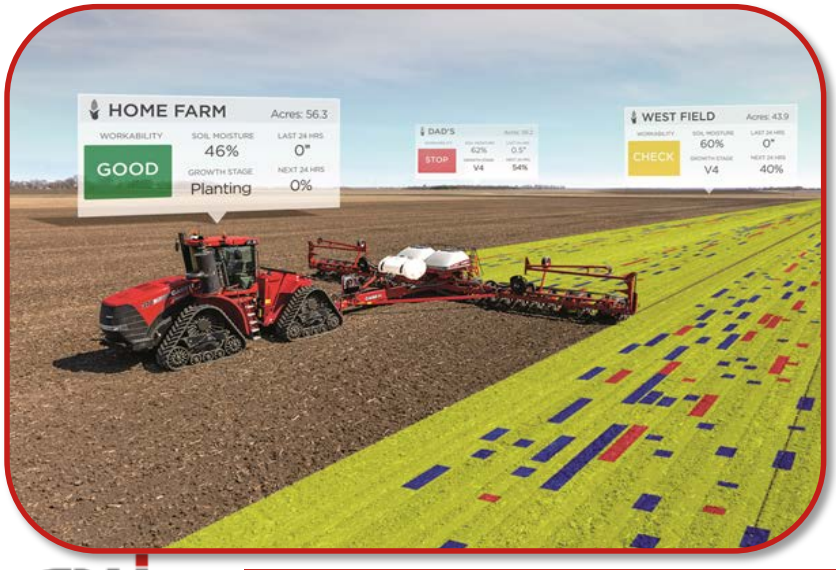






*Photo credit: Precision Planting*

# Remote Machine Supervision and Coordination

Next generation machine control, support and efficiency.

## Telematics and fleet management

- Remote fleet monitoring and adjustment
- Manage the output, not just the task
- Coordination and cohesion
- Reduced waste, improved performance
- Site specific control, real-time

AFS ADVANCED FARMING SYSTEMS

# Harvest and Row Track Technology

Reduced soil compaction to target of 1.3 g $cm^{-3}$

## Track Technology

- Reduced compaction
- Wider operating envelope
- Timely operations and harvests
- Tractive efficiency
- Water infiltration and runoff
- Crop performance and yield
- Productivity

## Harvest and Applicator Logistics

- Reduced collisions
- Reduced fatigue
- Crop loss and spillage
- Improved fuel use
- Productivity logistics
- Coordinated Vehicle Control

# Seeding and Nutrient Application Technology

Reduced rates, field loading and cost

## Nutriplacer 2800 liquid section control

- Improved NUE, 4R's
- N timing and placement
- Variable rate technology

## Precision Disk Drill 500/T for Cover Crops

- Retain BAP/DAP on landscape
- Protect soil from $E_k$
- Rotation effects

# ISOBUS Class-3

Implement data input for improved vehicle performance


## Implications for forage management

- Reduced operator fatigue
- Data-based decision models
- Charge control
- Slice control
- Consistent product
- Improved efficiency and productivity

## Implement dictates tractor speed

- Reduced clutching and breaking
- Reduced operator fatigue
- Consistent output
- Improved economy and performance

# Augmented Reality.

Uses sight/sound/other for enhanced graphical depiction or animation within view.


- High speed crop scouting
- Technical setup and repair
- Operator training
- Interactive mapping
- Machinery data immersion
- Observation enhancement
- NIR-NDVI mode
- Fertility mode (N, P, K, Fe, etc.)
- Operational training

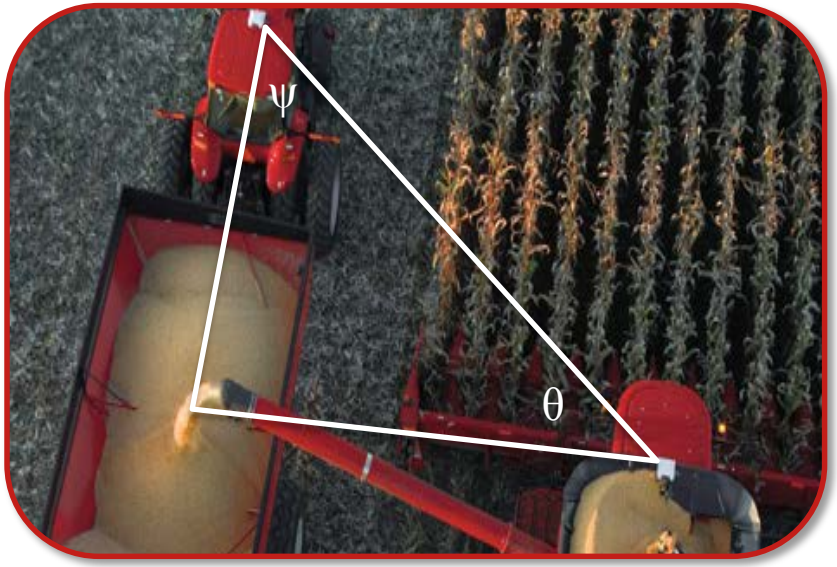
Photo credit: BMW

# Engine, Cooling and Hydraulic Technology

Patented SCR solution reduces C emissions


## Engine Emissions Technology

- Reduced NOx SOx emissions
- No EGR and burnout requirement
- Pure solution. No regeneration.
- Telematic monitoring: diagnostics/analytics
- No malware to detect test conditions




## CVC, V2V, Autonomous vehicles

- Labor efficiencies, machine optimization
- Controlled traffic, reduced C emissions
- Scaling technology vs machine size
- Improved productivity and safety
- Reduced vehicle costs

# UAV-Drone Scouting; NDVI-EVI-ADVI

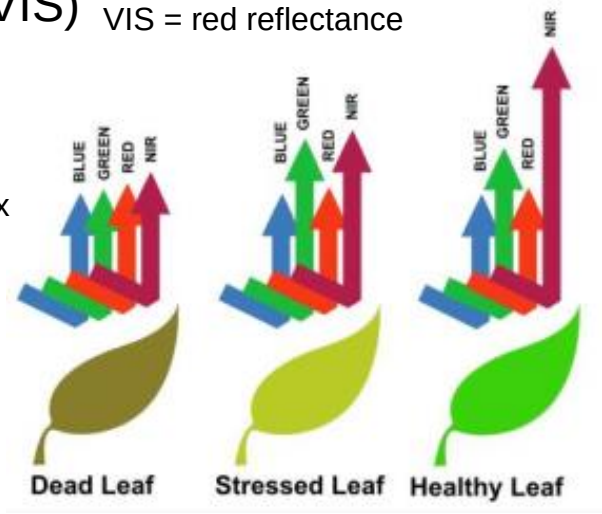
FAA regulations and compliance. (Normalized Difference Veg. Index)

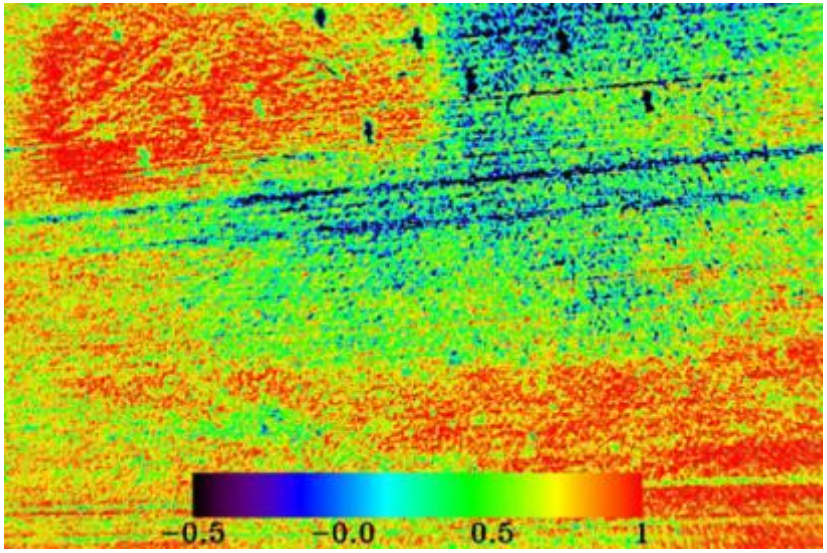
NDVI = (NIR-VIS)/(NIR+VIS)

NIR = near infrared reflectance
VIS = red reflectance

- Crop scouting supplement
- Tool in crop interpretation

EVI = enhanced vegetation index
blue instead of red λ




Emerging wheat stand

NDVI

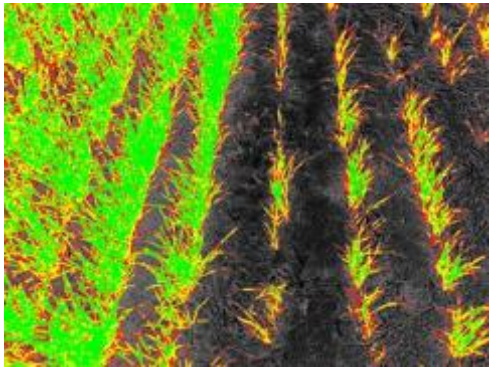


Photo credit: Agrobotix Inc.

# Application Equipment Technology

Reduced rates, field loading and cost


## AIM Command Pro

- Droplet size independent of ground speed
- Improved weed control and efficacy
- Reduced drift, off-target
- Section control
- Nozzle-by-nozzle turn compensation

## Direct Injection

- No tank pre-mixing, or rinsing
- No cross contamination
- Easier chemical changeover
- Eliminate waste and disposal issues
- Easy to add to an existing sprayer

# Improved Water Conveyance

Inside field boundaries no longer require overlap of seed and fertilizer.

Photo credit: Medina Cty. SWCD

## Water Management

- Improved waterway establishment
- Precisely defined and sculpted
- Improved waterway maintenance
- Reduce rill and gully erosion
- Limit non-point water pollution
- Reduce surface water eutrophication
- Supports multipurpse land use

Photo credit: Utah St. Univ.

## Riparian Zones

- Stabilize field-water intersection
- Enhanced wildlife
- Restore species diversity

# Conclusions:

- **Soil Health** working definition continues to evolve
- **Soil Health Index** could be improved with additional holistic parameters
- **Standards for** of external input levels largely absent: chemical, genetic, nutrient, other
- **Unintended consequences** from over-reliance on past technology
- **New data management tools** are coming online to assist
- **Machine delivery systems** with technology can potentially benefit soil health

*"A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise." – Aldo Leopold.*