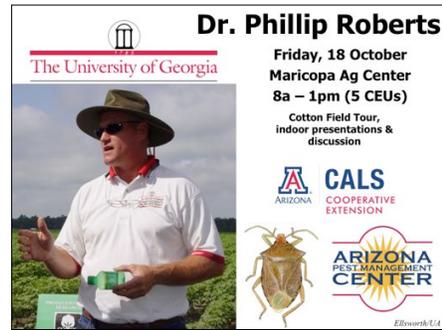
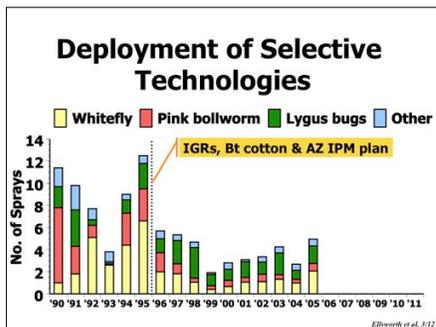


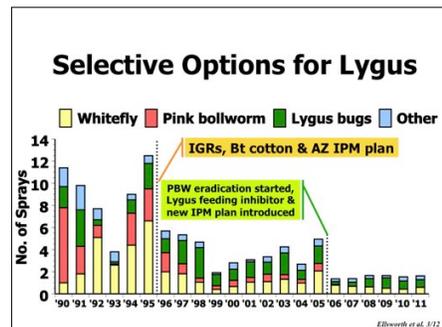
On 17 October 2013, we will host Dr. Phillip Roberts from the University of Georgia and expert on stink bug biology, ecology and management in a meeting co-sponsored by the University of California Cooperative Extension and the Arizona Pest Management Center. Due to the heightened role of brown stink bug in cotton and concerns centered around its control, we have produced this event so that growers and PCAs have access to one of the world's foremost authorities on this topic. We hope you can join us in Blythe, CA, or in central Arizona the following day.



Dr. Roberts will also speak at the central Arizona Farmer Field day on 18 October 2013, where we will also have a field and plot tour of efficacy and other insect and weed management trials. This event will also feature Dr. Jeff Silvertooth, Director of Cooperative Extension, as well as other Extension faculty.



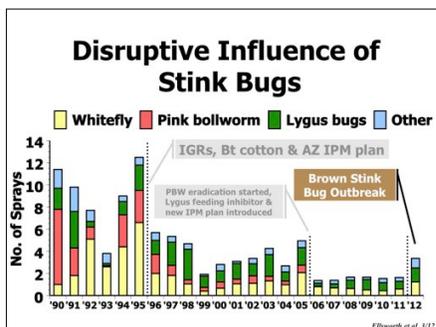
Cotton insect management is a case history in the thoughtful deployment of selective technologies to overcome a pest management crisis that culminated in over 12 insecticide sprays per season in 1995. Selective IGRs & Bt cotton as part of a complete IPM plan with a comprehensive outreach campaign that consisted of extensive grower and pest manager education were deployed in 1996 and immediate relief was measured. The results were striking. Insecticide use was cut at least by 50% over this period.



In 2006, we assisted the industry in the deployment of another set of technologies. Growers gained access to a selective Lygus (a mirid pest) feeding inhibitor [flonicamid (Carbine)] along with a major pink bollworm eradication campaign and an IPM plan taught to growers and pest managers throughout the state.

This change led to a halving of insecticide use and an expansive 6-yr period of very low usage (ca. 1.5 sprays for all insect/arthropod pests).

Adapted from Naranjo & Ellsworth 2009 & Ellsworth, unpubl.



Things changed in 2012 with the advent of increased importance of the Brown Stink Bug, a pest that had not broken out in Arizona cotton fields since 1963. The broad-spectrum chemistry required to combat this pest was very disruptive to the natural controls previously maintained through selective technologies. The result was not just more spraying for BSB but as well for Lygus, whiteflies, and secondary problems with mites and other pests.

Adapted from Naranjo & Ellsworth 2009 & Ellsworth, unpubl.

*"Late Summer" Pinal County Agronomic Workshop
Marana, AZ*

Chemical Use Data & Predicting Resistance Problems

Peter C. Ellsworth, Xianchun Li, J.C. Palumbo, Yves Carrière, Al Fournier, Wayne Dixon

Arizona Pest Management Center
University of Arizona & Cotton Incorporated

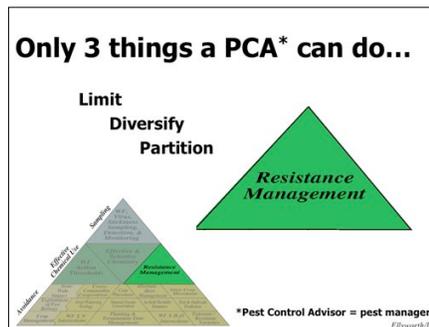
ARIZONA CALS COOPERATIVE EXTENSION COTTON

This presentation addresses the increase in chemical use to control insects by reminding growers of the importance of resistance management.

This presentation focuses on Bemisia whiteflies & depends on research and insights provided by my co-authors.



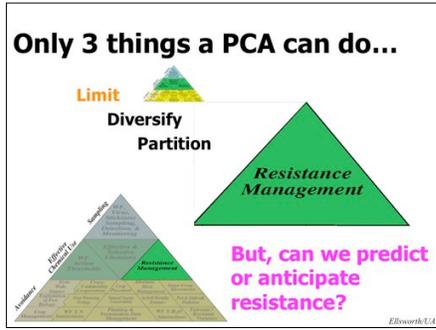
For years, we have taught growers about the 1st principles of resistance management, which is very much a component of any IPM plan.



A practitioner, a PCA, can only manage resistance in one or more of three ways:

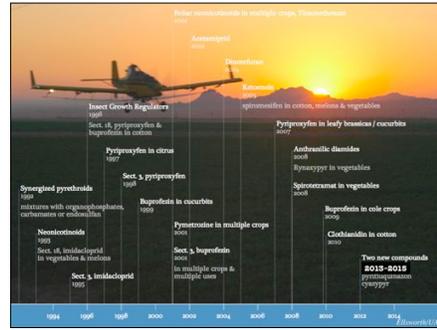
- 1) Limit his/her use of the chemistry to the lowest practical level,
- 2) Diversify the modes of action used, and
- 3) Partition chemistry through space or time so as to provide relief from resistance selection in certain crops or at certain times.

That's it. Practically speaking, these are the only tactics of resistance management available to the user.

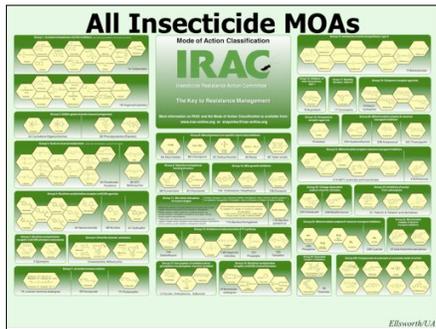


So let's focus on the first one, Limit chemistry. How does one do that? I would say you do that by practicing good IPM! If you are, you are already employing a suite of avoidance and prevention tactics and observing action thresholds that help limit the number of sprays made.

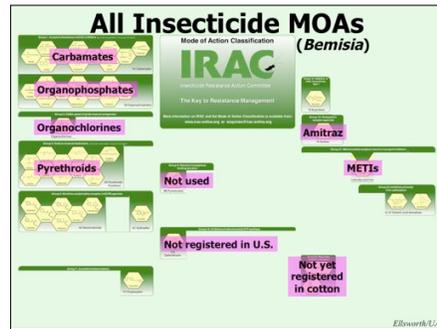
But advancing resistance management into the future, we need to ask, "can we predict or anticipate resistance?" Especially in a way that arms producers with tools to overcome or mitigate resistances that impact their production.



A false sense of security may be had by examining all the new products and modes of action registered over the last 20 years, all focused on whitefly management in cotton or other crops.

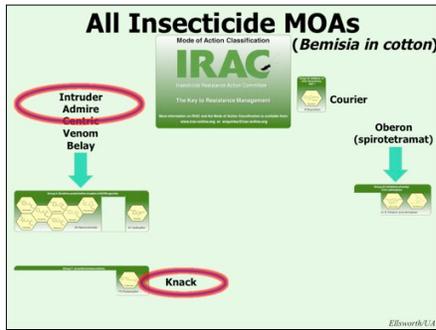


But in fact, modes of action are a precious resource and are limited at any given point of time. This is where we are today with regards to all MOAs for arthropod control worldwide in all cropping systems.



These MOAs are active against whiteflies, perhaps just 12 MOAs, and not all of these are equally effective or useful.

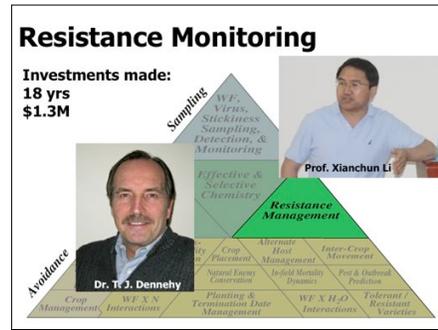
We wish not to use any of the original 5 MOAs as they are broadly toxic and disruptive to our system (and some have since been removed from the market; i.e., endosulfan and amitraz, and some OPs). A couple are not used because they do not provide adequate commercial level control in our system (METI's & selective homopteran feeding blockers). One is not registered in the U.S. and likely never will be (difenthiuron), and another is yet to be registered in U.S. cotton (as of 2013; diamides).



This leaves us with perhaps just 4 available MOAs, which has been the case since 2005 with the registration of spiromesifen (Oberon). [Note we lost all uses of endosulfan in 2012].

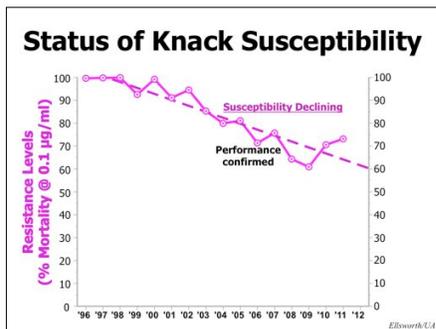
We have two modes of action, neonicotinoids group 4A [especially acetamiprid (Intruder) & imidacloprid (Admire)] and pyriproxyfen (Knack) each threatened by advancing resistances. And some of the new chemistry is not yet registered in cotton [spirotetramat (Movento)].

Right now (2013), we have only 2 modes of action that are relatively safe from resistance and are fully effective on whiteflies [buprofezin (Courier) & spiromesifen (Oberon)].



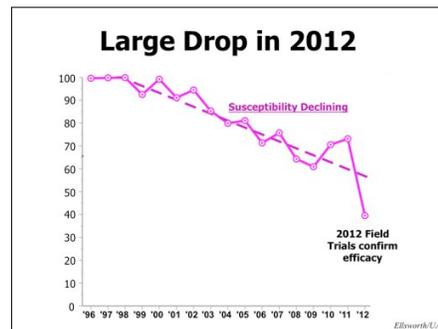
Dr. Tim Dennehy (former UA faculty) established and operated a statewide resistance monitoring infrastructure. Dr. Xianchun Li took over the responsibility for this project of statewide resistance monitoring of Bemisia in cotton and other crops (2008–).

How can we use the investment of over 18 years of resistance monitoring data and information and cotton industry grant investment of \$1.3M in this activity?

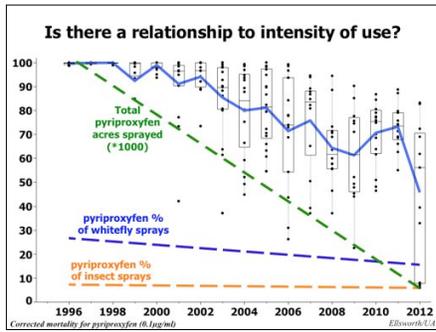


We have long-standing information that suggests resistances to Knack have been around for awhile, albeit a 4-year study of resistance dynamics and field performance showed that the resistances of that time (2004–2007) were not degrading performance of Knack in the field. It is important to recognize the decoupled nature of lab assay resistance inferences and actual field performance. They do not always run completely in parallel. For example, our direct observations of treatments made over the last two years seem to still show that Knack is performing quite well.

Nevertheless, the trend line is disturbing and represents risk in our system. Susceptibility is declining based on lab testing of field-collected whiteflies from around the state.



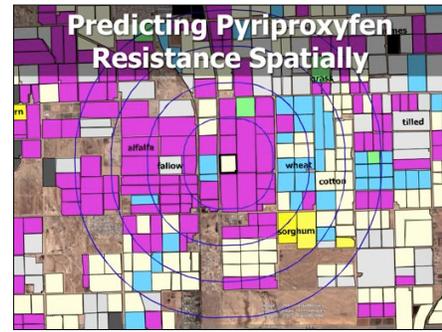
The 2012 drop in susceptibility is particularly disturbing. What does this mean? Are we in danger of losing significant efficacy of the product (Knack)? Why is this happening now?



In such a striking trend over time, one would expect that selection pressures [i.e., pyriproxyfen (Knack IGR) usage] had progressively increased over time. However, that is not the case at all. Actual usage in total acres sprayed statewide has declined progressively over this same period. Even if we examine pyriproxyfen (Knack) sprays as a % of Bemisia sprays made or of all insect sprays made, we note a declining or neutral trend, certainly not an increasing one.

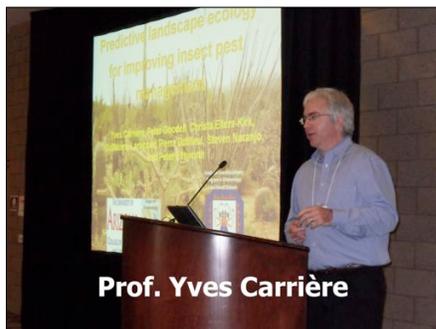
This makes it difficult to understand how to advise pest managers and predict when and where they should expect to see declines in susceptibility and possible reductions in performance.

It should be noted here that pyriproxyfen has always been constrained to just 1 spray per cotton season.



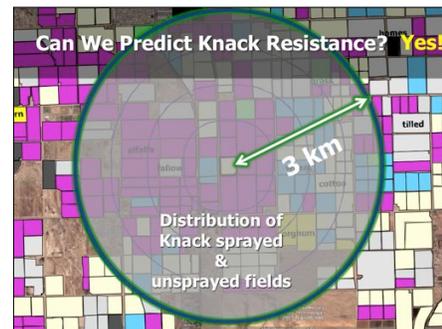
The answer may be in examining more local dynamics of the system. Can we predict Knack resistance spatially just by knowing something more about the local practices?

[2007 FF#47]



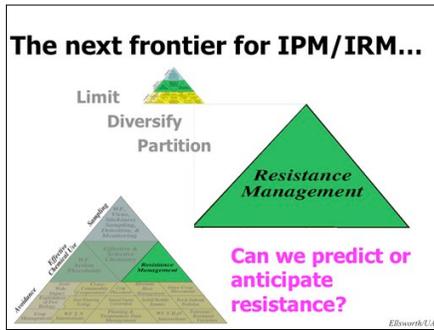
Prof. Yves Carrière

Dr. Yves Carrière has been working with spatial ecological datasets and helped pioneer an approach to the analyses of these types of data. Many of us have collaborated with Yves, including on the dynamics of Knack resistance spatially in Arizona cotton.

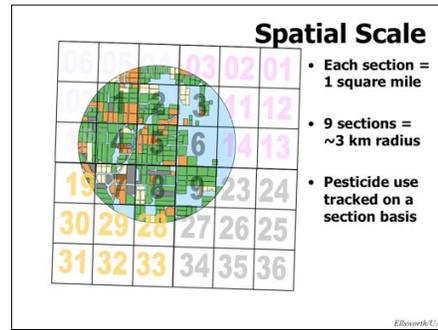


The information needed to predict risks of pyriproxyfen (Knack IGR) resistance locally can be found within 3 km of the cotton field of interest, coincidentally the same "resistance management" unit we taught growers about 10 years earlier in our cross-commodity guidelines. We surmise from this that in fact the resistance management unit of interest over which whiteflies interact & develop resistance to all chemistry may be ~ 3km radius around a subject field. In essence, our statewide surveys & pesticide usage were too coarse a measure to conclude things definitively about when & where pyriproxyfen resistance might develop. But this showed us that in a community where some growers depend on and use Knack in every cotton field every year, all growers are at greater risk of having Knack resistance affect them even if they had never used Knack there before!

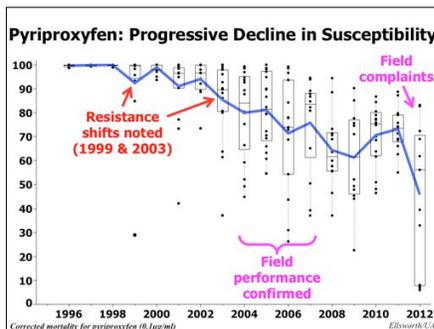
[2007 FF#47]



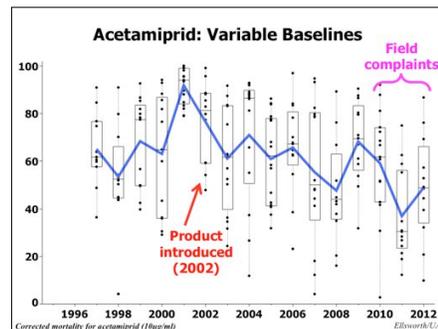
The next frontier for IPM and IRM is to get beyond the resistance retrospectives that are tantamount to the coroner arriving on the scene of a tragic accident hours later and pronouncing the “patient” dead. We have to ask, are there ways that we can predict or anticipate resistance? This latest study on Knack resistance provides an opportunity to address this fundamental question.



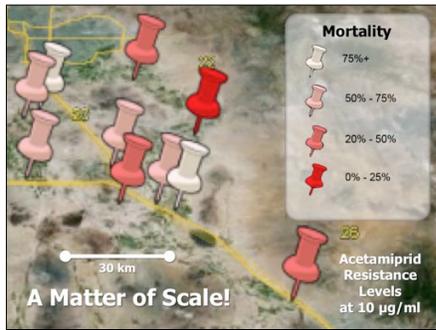
To understand this question we need to examine the ecological unit of resistance management that is proposed here. Based on whitefly movement biology & ecology, we believe that whiteflies are functionally reproducing within a spatial context of a 3 km radius from a subject field. In the western U.S., land is organized around sections that are about 1 mile square. 9 sections taken on a 3 x 3 grid are roughly representative of this 3km community. We have access to pesticide records which are tracked on a section basis. Through analyses of these records, we should be able to show where whitefly insecticides are used a great deal and where they are less intensively used.



Pyriproxyfen (Knack IGR), in hindsight, shows an extremely consistent & progressive decline over time in susceptibility of Bemisia. The dosage that killed 100% of whiteflies in 1996–1999 has been killing substantially fewer whiteflies progressively over time. Tim Dennehy noted the 1st decline in 1999, but no specific action was taken. He noted another shift in 2003 & this prompted additional research into field performance of pyriproxyfen in 2004–2007. The conclusion was that pyriproxyfen was working as well as it had ever been, despite the apparent shift in susceptibility, a testament to pyriproxyfen’s dependence on the biological activity of conserved natural enemies & other natural forces that we refer to as “bioresidual”. We have received a limited number of field complaints starting in 2012, 17 seasons after introduction of this MOA. A large step-wise shift in the resistance monitoring data occurred in 2012, too.



The data for acetamiprid (Intruder), a key neonicotinoid, are less definitive, in part because of widely variable baselines measured prior to the introduction of this product in Arizona (1997–2001). While declines in susceptibility appear to have taken place, no specific changes were made in guidelines after 2003. Field complaints received from growers started in 2010. The industry, in response (2012), petitioned USEPA for a Special Local Needs (SLN) registration in AZ cotton of a maximum rate increase by 50%. Commercial-scale evaluations showed that this higher rate was sufficient to kill Bemisia very well, as well or better than at any other time. Based on the Knack study, we believe that Intruder & other neonicotinoid usage over a small community may be predictive of the progression of resistance in an area. [Each dot represents one field population.]



The statewide trends just shown do not always correspond with user's experience with Intruder (or other control chemicals).

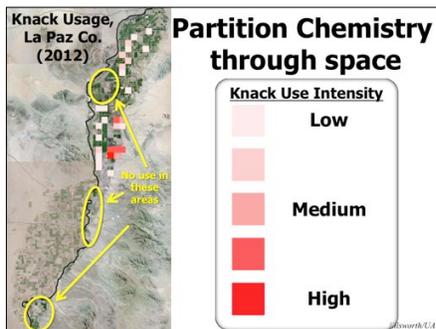
We believe this is a matter of scale. The former data displays trends averaged over all populations throughout the state. These data for acetamiprid (Intruder) show that populations we would expect to be highly resistant (dark red) can be located fairly close to populations that test out as quite susceptible. So from Eloy to Arizona City or Coolidge or Casa Grande may each show very different local resistance dynamics.

2010 Acetamiprid resistance levels



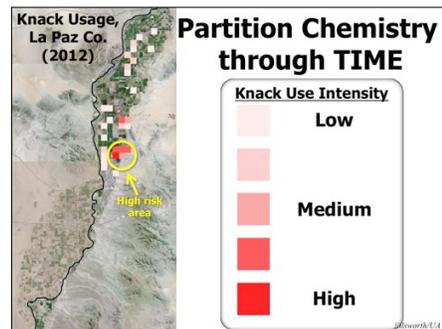
The answer we believe may be in examining more local dynamics of the system. Carrière and colleagues showed that we can predict pyriproxyfen (Knack) resistance spatially just by knowing something more about the local practices, specifically the fields where Knack was used or not.

[2007 FF#47]

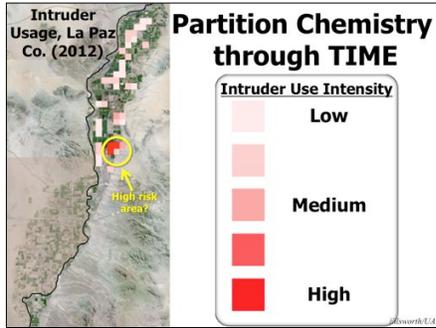


We can produce chemical use maps that show recent trends of use such as this one of Parker Valley for pyriproxyfen (Knack IGR) usage in 2012. So now, we can begin to arm growers with information that permits them to partition chemistry, locally, through space. In this example, growers in the middle of the valley used pyriproxyfen sometimes intensively in some areas. But growers in the other parts of the valley, for whatever reason, did not use pyriproxyfen. This effectively has partitioned the chemistry over space & could become a directed management practice by these growers in the future.

This helps provide refuges for whiteflies that are needed to reduce selection pressures for resistance.



And, in some local "communities", areas defined by a 3x3 section grid or a 3km radius, we can advise a grower who has intensively used pyriproxyfen that his/her area will be subject to high risks for pyriproxyfen resistance in the next year. The advice would be to partition chemistry through time, or in this case, to forgo the use of pyriproxyfen in this specific location in 2013 after having used it intensively in 2012. Effectively this grower possibly needs to skip a year of use for pyriproxyfen.



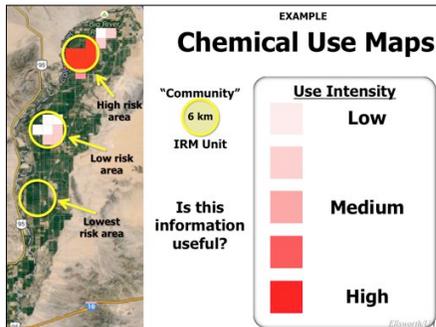
As it turns out, this area also used Intruder a great deal, perhaps pressure was extreme and both compounds were needed. But also perhaps because they mixed Knack with Intruder. While this practice has been popular at times with the intention of "knocking down" adults with Intruder and getting long-lasting control of eggs and immatures with Knack, this practice risks the simultaneous selection for resistance to BOTH compounds.

So this growers should carefully consider whether Oberon and/or Courier can better meet their needs in 2013 and avoid usage of both Knack and Intruder for a time.

So what does this mean?

- Scale over which whitefly resistance operates
- Rich source of information on pesticide use
 - Areas treated with a product
 - Areas not treated with a product (refuges)
- Cusp of predicting conditions that advance resistance
- A new tool? Ability to locally partition chemistry through space & time

Truly, this is a significant potential advance in our understanding of whitefly resistance that gives us access to a potential new tool for pest managers to consider in developing their IPM and resistance management plans.



So how would this work?

In this fictional example, the APMC would publish maps like this showing the distribution of usage of different whitefly products. Just by inspection, a grower and PCA could discuss which areas nearby are at higher or lower risks for future resistance development. They would not have to depend on hearsay or conjecture on what was used by neighbors. We have this capability and could publish these maps annually during the winter prior to each cotton season.

Is this information useful? Desirable?

Is this a good use of pesticide use information?

- Capability
 - Pesticide Use Maps for critical chemistries
 - Resistance monitoring information, statewide
- Equipping pest managers with a new tool
 - Examine past year's pesticide use distributions
 - Make current year pesticide decisions based in 1st Principles of resistance management and on understanding of past pesticide use & resistance patterns
 - Ability to locally partition chemistry in space or time
- Prospective Resistance Management (not reactive)

We have this important new capability and understanding.

We could equip growers and pest managers with a new tool and a new way to think about pesticide use as it relates to 1st principles of resistance management and to future decisions about product choices. The discussion and decisions would be their own, but now they could effectively partition chemistry in space or time locally and hopefully effectively so that resistance does not advance further.

This is a lesson in prospective resistance management, reducing our chances of only reacting once there is a significant problem in the field.

Is this a worthwhile approach?



Thanks to the many growers, pest control advisors and others who have collaborated & supported this project. Specific thanks to the USDA-NIFA Extension IPM program, to Cotton Incorporated, and to the Arizona Cotton Growers Association.

The Arizona Pest Management Center (APMC) as part of its function maintains a website, the Arizona Crop Information Site (ACIS), which houses all crop production and protection information for our low desert crops, (<http://cals.arizona.edu/crops>), including a copy of this presentation.

Photo credit: J. Silvertooth