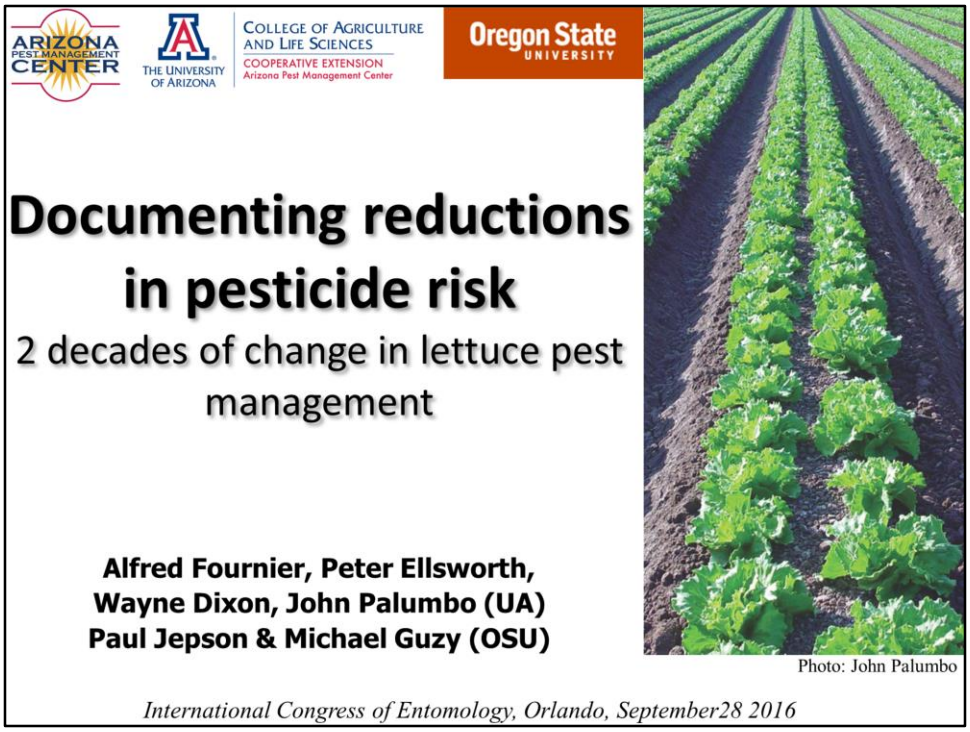


In this project we examined 23 years of pesticide use data from Arizona lettuce production, and quantified ecotoxicologial risk using the ipmPRiME.org database housed at Oregon State University.

This was truly a group effort. I want to acknowledging my coauthors. Paul Jepson and Michael Guzy of Oregon State University were part of the team that developed the Pesticide Risk Mitigation Engine, or ipmPRME as we call it, and they did the risk calculations. The rest of our team at UA includes Peter Ellsworth, who worked with the data and developed the charts, Wayne Dixon, who manages our Pesticide Use Database, and John Palumbo, Vegetable Extension Entomologist who advised us on many aspects of the data and the lettuce production system.

Arizona Lettuce Facts

- About 95% of all fresh lettuce consumed in the U.S. in the winter
- Fresh lettuce production value (2015) over $705 million (head, leaf & romaine) (NASS)
  - 20,900 ac Romaine
  - 32,500 ac Head
  - 9,300 ac Leaf
- Additional production (Palumbo, pers. com.)
  - 15,000 ac Spring/Baby mix
  - 1,200 ac Butter
  - 100 ac Radiccio
- Produce Paradox (Palumbo & Castle 2009)

Source: USDA-NASS 2015

Our lettuce production is very intensive and supplies ca. 95% of the U.S. winter supply each year, valued at over $700mil in 2015. Yet, there are severe constraints on production, the main one being the so-called Produce Paradox, where consumers wish to have blemish free, practically perfect produce, yet they wish there to be no pesticides or risks associated with the produce they eat.

Pesticide Use Reporting

- **<100% use reported to AZ Dept. of Ag.**
- **Uses reported:**
  - **All custom (for hire) apps.**
  - **Aerial apps.**
  - **Ground Water Protection List**
  - **Some Section 18 pesticide registrations**

Arizona Department of Agriculture
Environmental Services Division
1688 W. Adams, Phoenix, AZ 85007
Phone 602-542-0901 Fax 602-542-0466 Web-site www.azda.gov

Office Use Only

Form 1080

Pest
Crop
Location
Product
Rate

Seller ____ PSP # ____ Date ____
Grower ____ PGP # ____ County ____
Pest Conditions ____ PMA Area ☐ Yes ☐ No

Harvest Date	Crop	Section	Township	Range	Acres	Label Days to Harvest	Crop	Section	Township	Range	Acres	Pesticide Application Date

Additional Field Description ____

Product/Brand Name	EPA Registration Number	Active Ingredient	Rate & Unit of Measure/Acre	Dilution/ 100 GAL	Total Chemical

Total Acres ____ Total Volume Per Acre ____ DEQ Soil Applied ☐ Yes ☐ No ____ Supplemental Label Required ☐ Yes ☐ No ____ ☐ Air ☐ Ground ☐ Chemigation Other: ____
Ground Water BMP ☐ Yes ☐ No
Label Restrictions/Special Instructions ____

Custom Applicator ____ Delivery Location ____
Grower/Pesticide Advisor's Signature ____ PGP/PCA Number ____
I, undersigned certify that the above instructions comply with Arizona Revised Statutes, Title 3, Article 6 and A.A.C. R3-3-302.

A.A.C. R3-3-302 PESTICIDE APPLICATION REPORT
I, the undersigned, certify that an application of pesticides was made by the designated applicator in strict compliance with the above recommendation and instructions on the date and under the conditions specified below.

Equipment Tag #	Time(s) of Application	Wind Direction & Velocity	Date(s) Applied

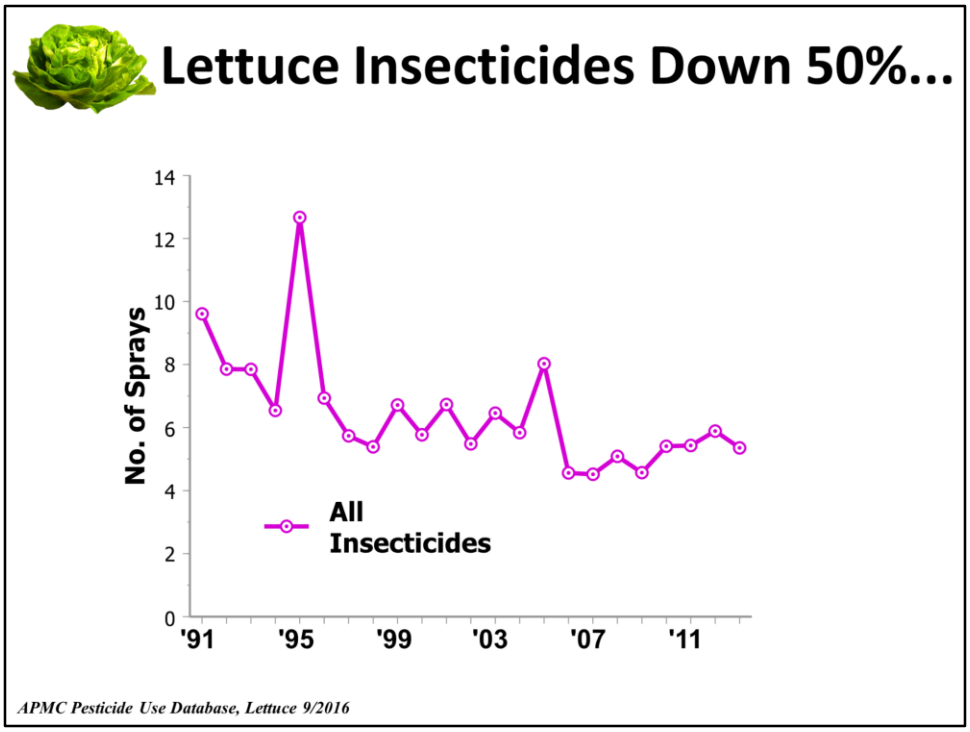
Deviation From Instructions ____
Company Name ____ PGP/CA # ____
Grower/Applicator Signature ____ PUP/PUC # ____
Print Operator(s)/Pilot Name ____ AAP #

THIS DOCUMENT MUST BE SUBMITTED TO THE ARIZONA DEPARTMENT OF AGRICULTURE NO LATER THAN THE THURSDAY FOLLOWING THE CALENDAR WEEK IN WHICH AN APPLICATION WAS COMPLETED.

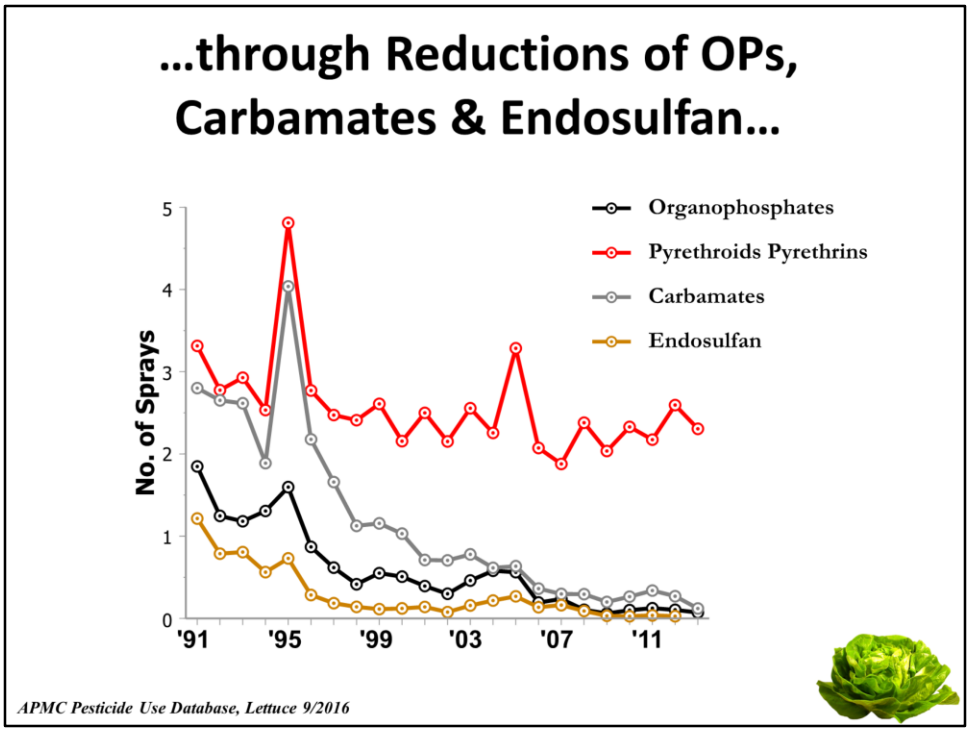
Copy Distribution: Two Copies to Applicator -- One Copy to Advisor -- One Copy to Seller -- One Copy to Grower --One Copy to ADA

The L-1080 form contains all the information relevant to pesticide application including the crop, pest target or targets, location (legal descriptions), product, rate, date of application and any deviations. We capture data submitted in our own database and invest in data verification and correcting of errors. These data support research, education and registration needs of the industry.

First we will look at insecticide use data for lettuce, from our database. This is for all lettuce types combined.

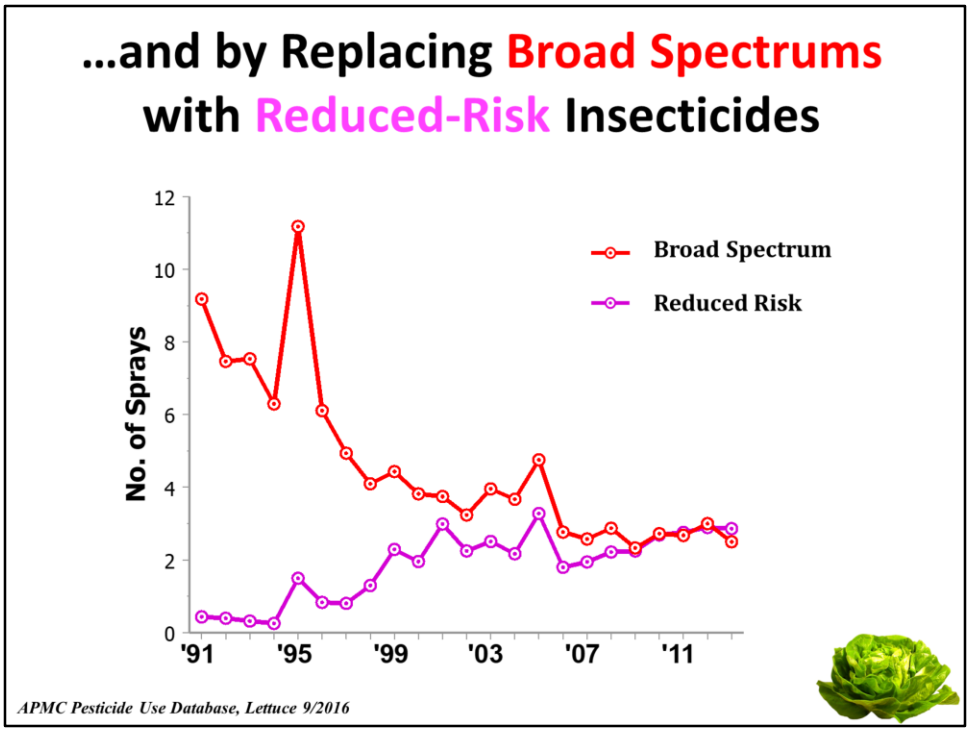


Using information from our Pesticide Use Database, this chart shows average annual number of insecticide sprays / acre, 1991 to 2013, showing about 50% decrease in number of sprays.



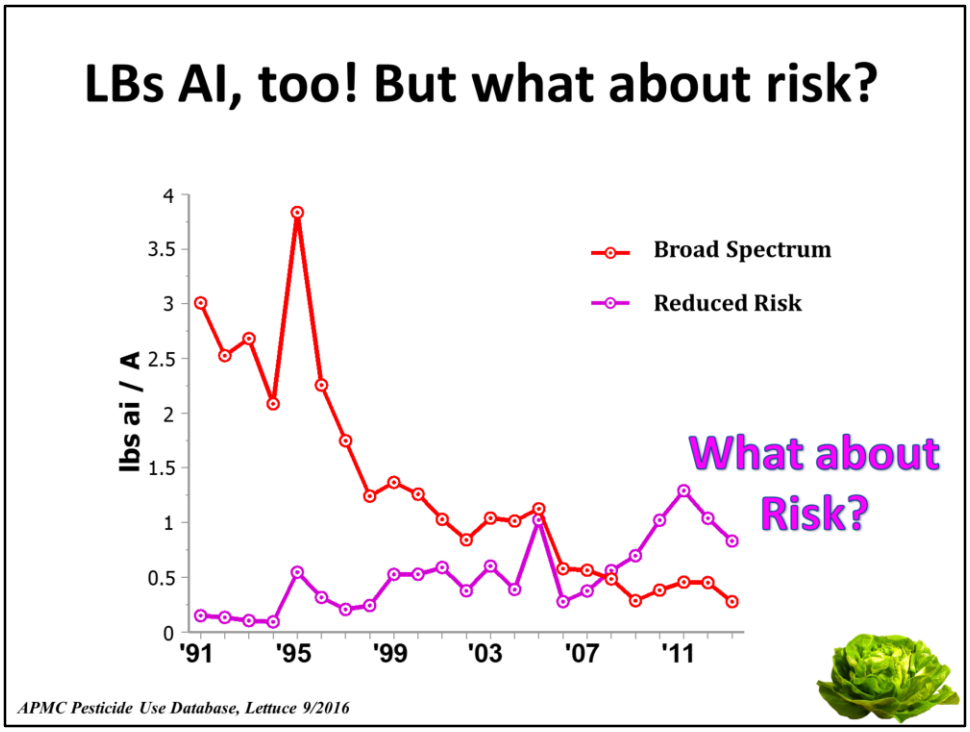
Most of this reduction in sprays is due to a deline in use of most broad spectrum insecticide groups such as carbamates, OPs, and endosulfan (which is no longer registered); Much smaller declines are apparent for pyrethroids.

33% reduction in pyrethroids
91% reduction in carbamates
95% reduction in OP's
96% reduction in endosulfan
72% reduction overall in broad spectrums
46% reduction in all insecticides



Here all broad spectrum insecticides are combined on the red line and shown with reduced risk insecticides shown in purple. These reduced risk compounds help to preserve natural enemies in the system. At this point, sprays of reduced risk compounds outnumber broad spectrums.

We have been showing these kinds of trends – reductions in insecticide use – for some time. While we generally assume that less pesticide means lower risk to people and the environment, we have not developed data that directly examines pesticide risk. And this is the next natural question: have we, in fact, reduced risk?



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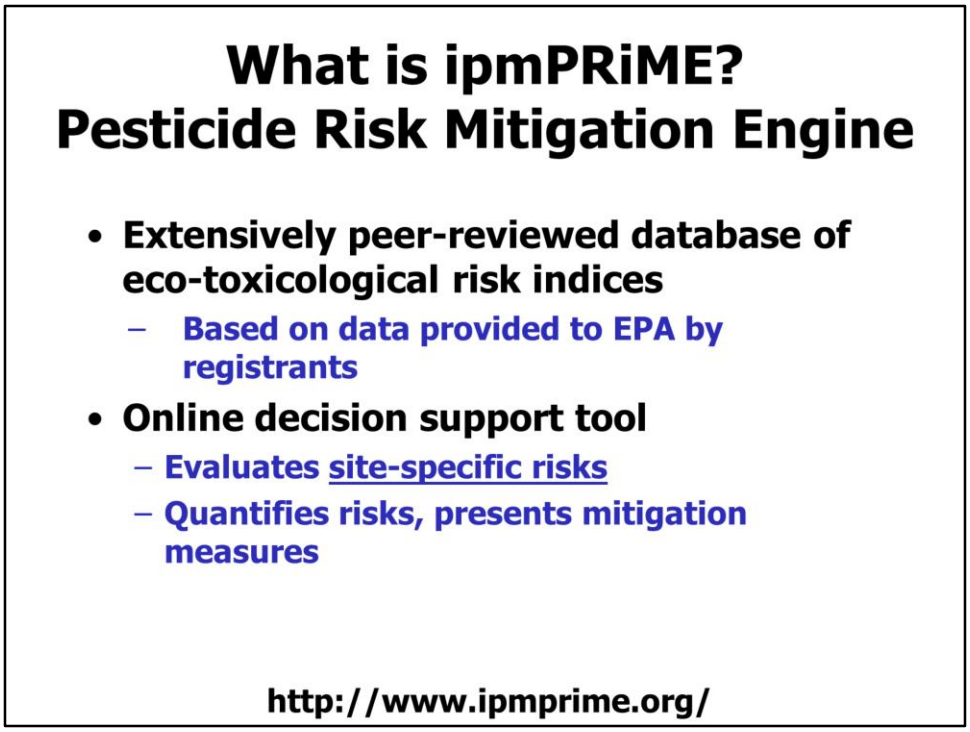
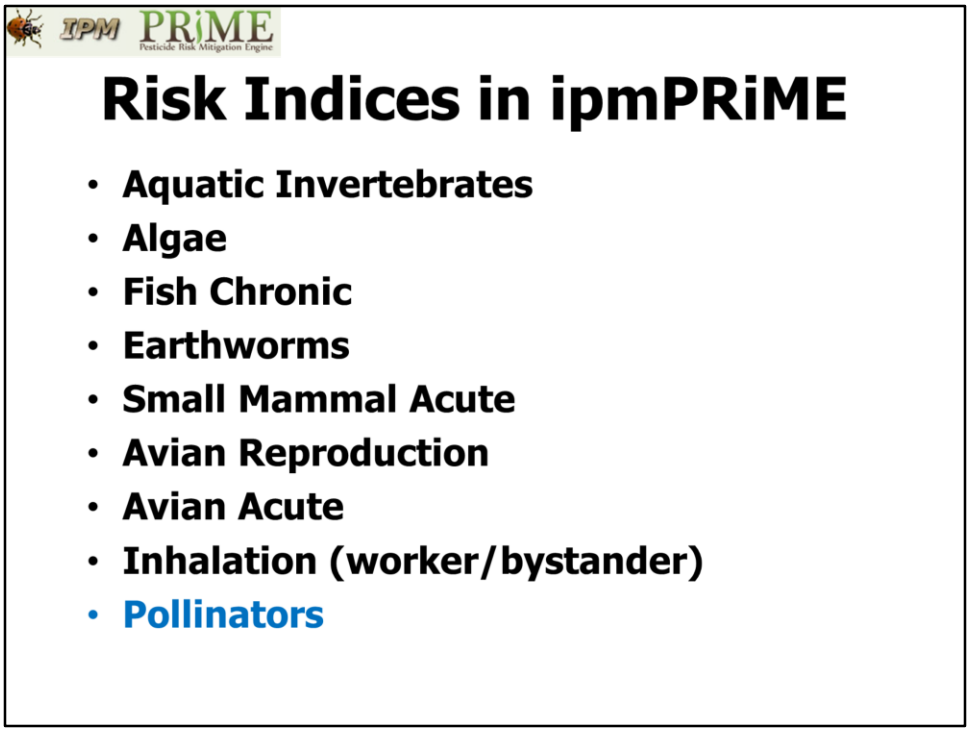
Risk Analysis

- Paul Jepson & Michael Guzy, Oregon State U
- Pesticide Risk Mitigation Engine (ipmPRiME.org)
- Ecotox. risk for all pesticides in AZ lettuce
- 1991–2013

I will highlight results from a project intended to quantify the "risk" of all types of pesticide applications in all types of Arizona lettuce, from 1991 through 2013. This was a collaborative project with Oregon State University colleagues Drs. Paul Jepson and Michael Guzy which was funded through two Arizona Specialty Crop Block Grants.



A pesticide's Risk is related to toxicity and exposure. ipmPRIME is a database of pesticide risk indices. It is the most respected and peer-reviewed such system in existence. Their database is built from data that registrants provide to EPA when products are registered. There is also on online pesticide risk mitigation tool used by growers to quantify risks on a real piece of ground and identify alternatives to reduce risk.

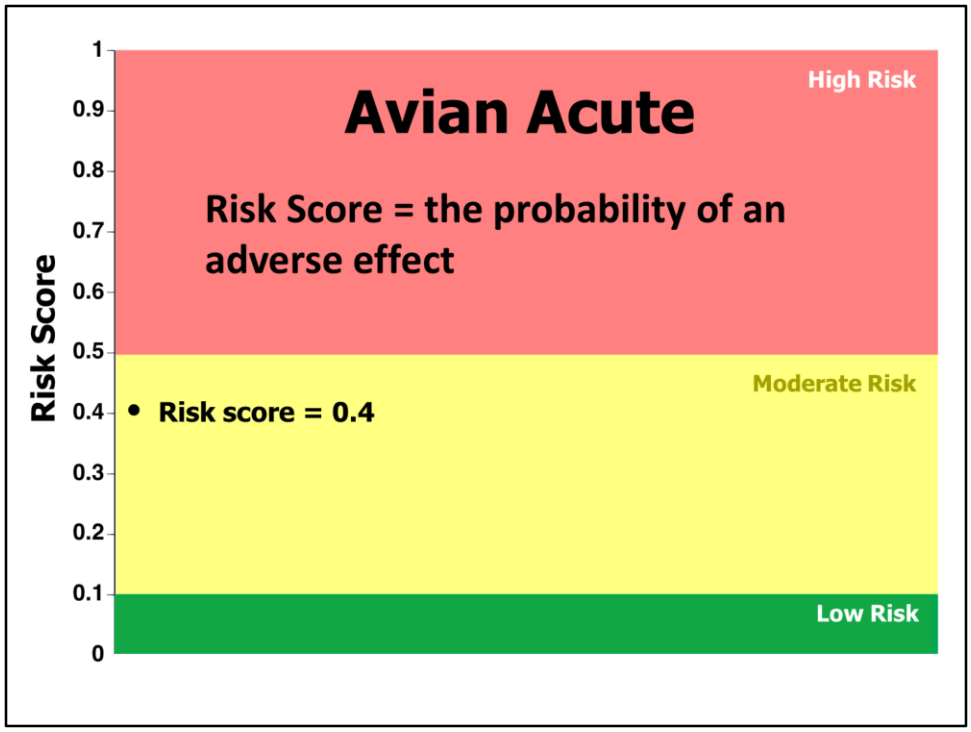


The 8 indexes listed in black are well established in PRIME. A pollinator index has been recently developed that calculates a hazard quotient in place of the risk score. This is a bit of a work in progress and I will not be presenting the pollinator data today.

Methods

- Prepared AZ lettuce pesticide use data
- Calculate risk scores using ipmPRiME
- Spatial analysis:
  - Mean Risk Score across all AIs applied on a section of ground for each index
  - Impact acres: mean proportion of a section impacted by the mean risk score

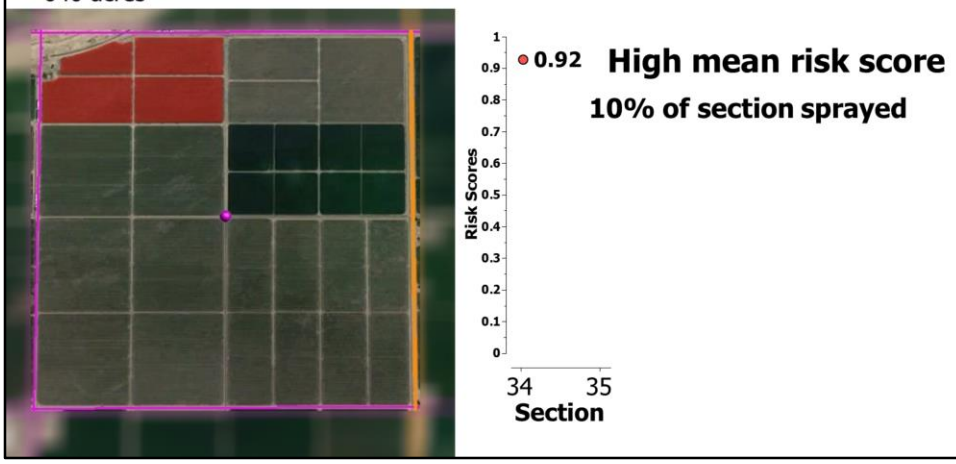
The UA Team prepared the lettuce pesticide use data for analysis.
The OSU group calculated the risk scores. (More on that in a moment.)
Today I will present 2 types of statistics from the analysis: the mean risk scores across all AIs applied for each year, for each index; and the impact acres, mean proportion of a Section impacted by the mean risk score



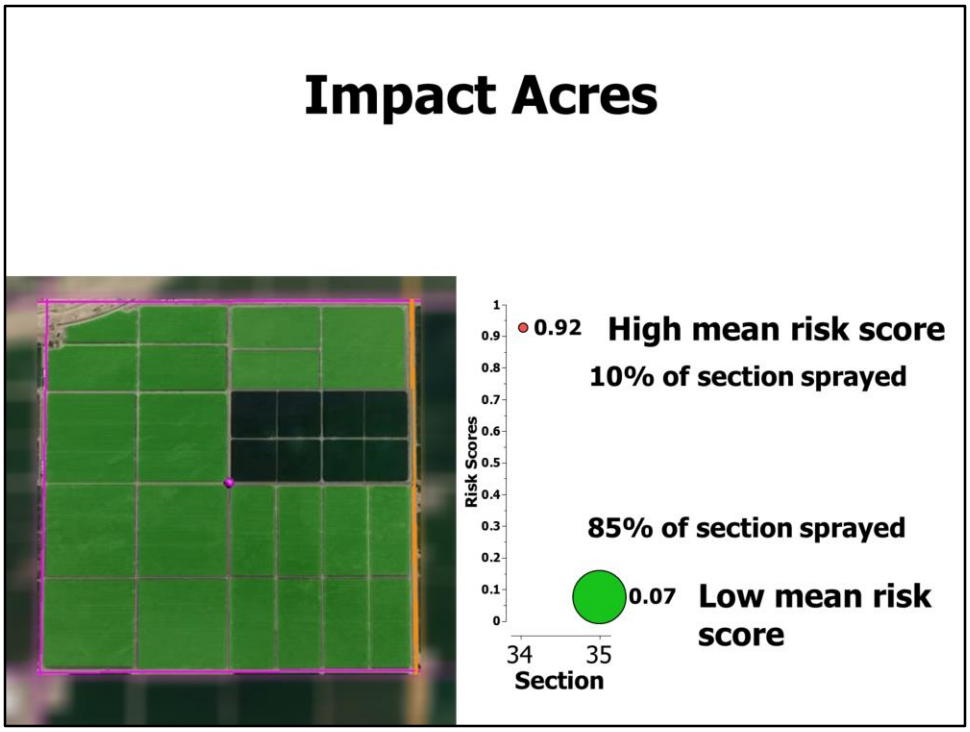
Risk Scores in ipmPRiME are probablistic. ipmPRiME is designed to *connect* critical doses and concentrations from lab studies to adverse effects of pesticides observed in field studies by way of a statistical model *that predicts* the potential for ecological injury from pesticide treatments.
Risk is related to both toxicity and exposure. The risk score represents the probability of an adverse event, for example, a bird kill.
Risk scores are categorized as low (below .1), medium (.1-.5) or high (above .5) as signified by the colors.
In this example for avian acute, this application has a 40% chance of harming birds.

Impact Acres
= sum[Acres * Mean(Risk)] / Section_Acres

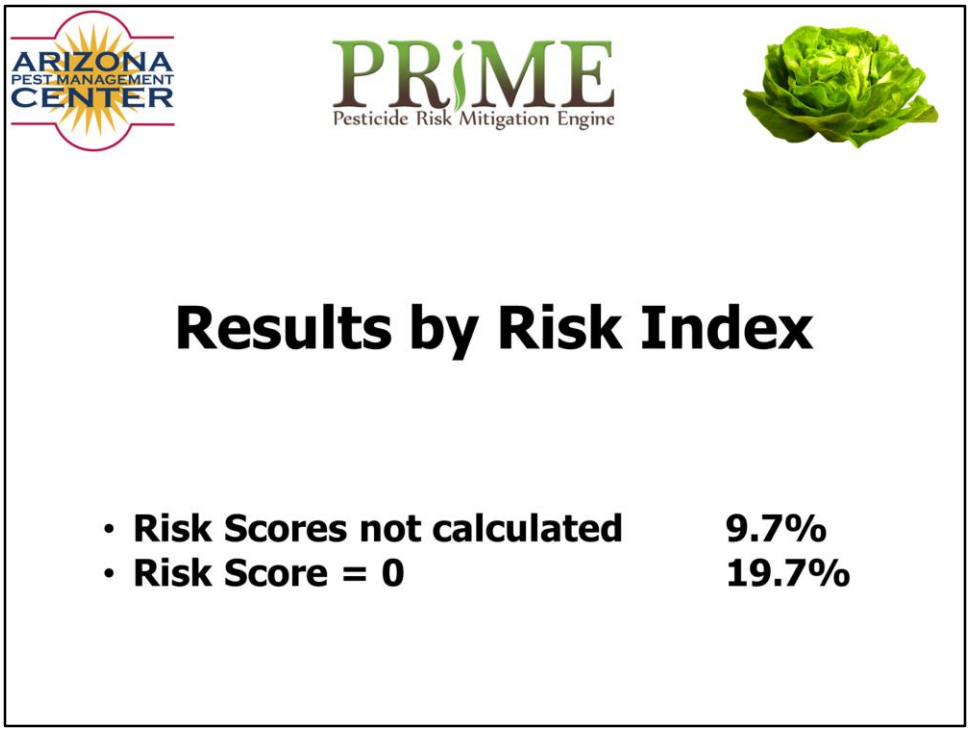
Typical Section = 1 sq. mile = 2.6 sq. km = 640 acres



We also examine "impact acres", the proportion of an area impacted by a particular risk score. You can have a high risk score on a small percentage of acres. Here, the high risk score of .92 only impacted 10% of the acres in section.
A Section is a legal description for an area of land. Sections in AZ vary in size but are typically 1 square mile = 2.6 sq. = 640 acres.

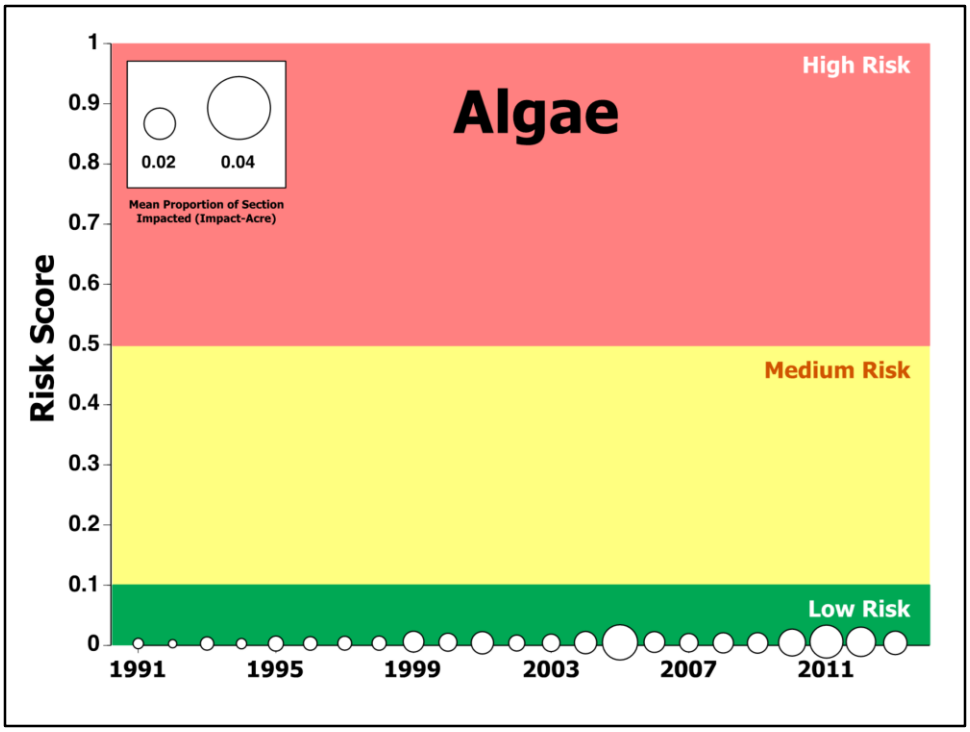


We also examine "impact acres", the proportion of an area impacted by a particular risk score. You can have a high risk score on a small percentage of acres. Here, the high risk score of .92 only impacted 10% of the acres in section.
…Or a low risk score on a large percentage of acres. Here in the lighter green you see a low risk score of .07 that impacted 85% of the section.

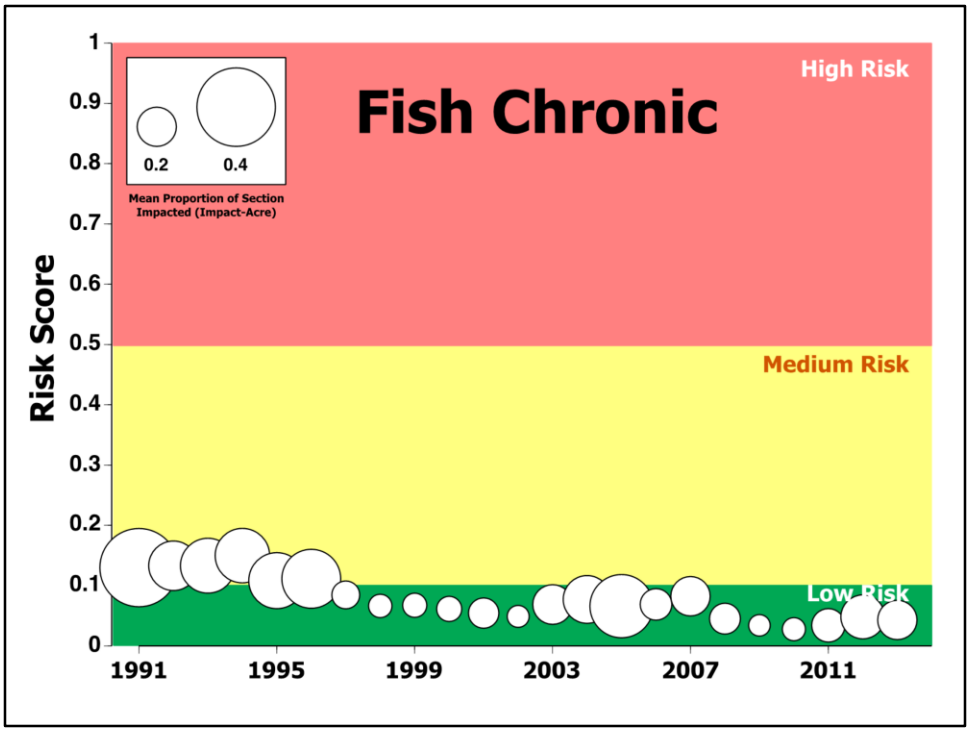


I will present separate results for each of the 8 Risk Indexes. This is important because risk can vary greatly by index for a single AI. ipmPRiME does not over-simplify results by averaging across indexes.
9.7% of the time, risk scores were not calculated because there was not sufficient toxicological data available for some AIs.
Risk = 0 in almost 20% of the time when scores were calculated.

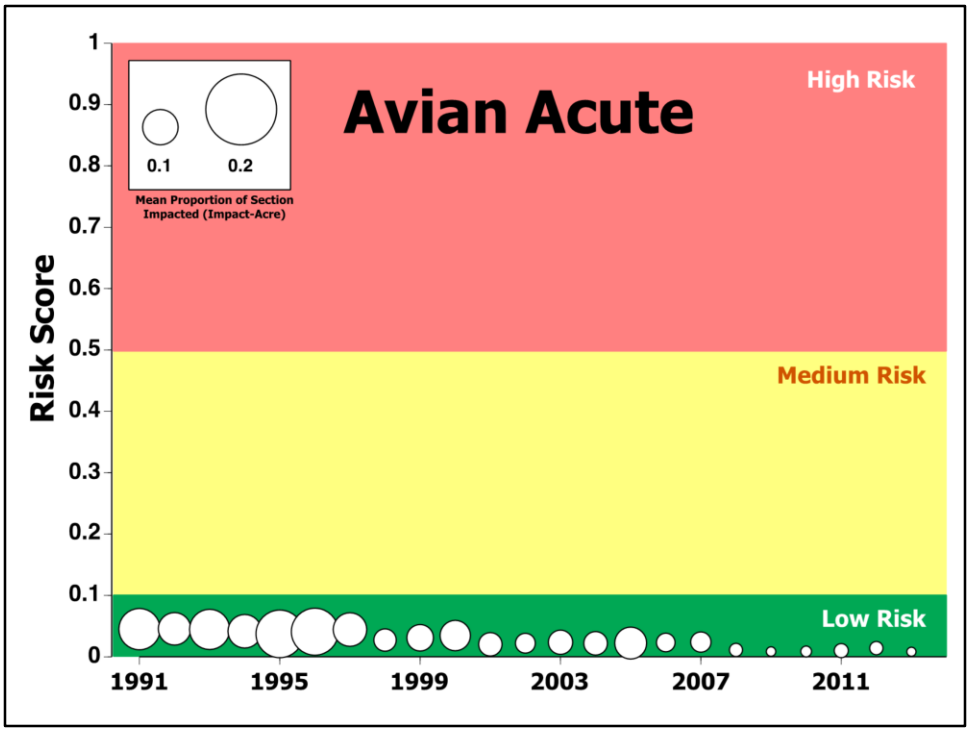
I will share risk results in Impact Acres for all types of lettuce statewide.



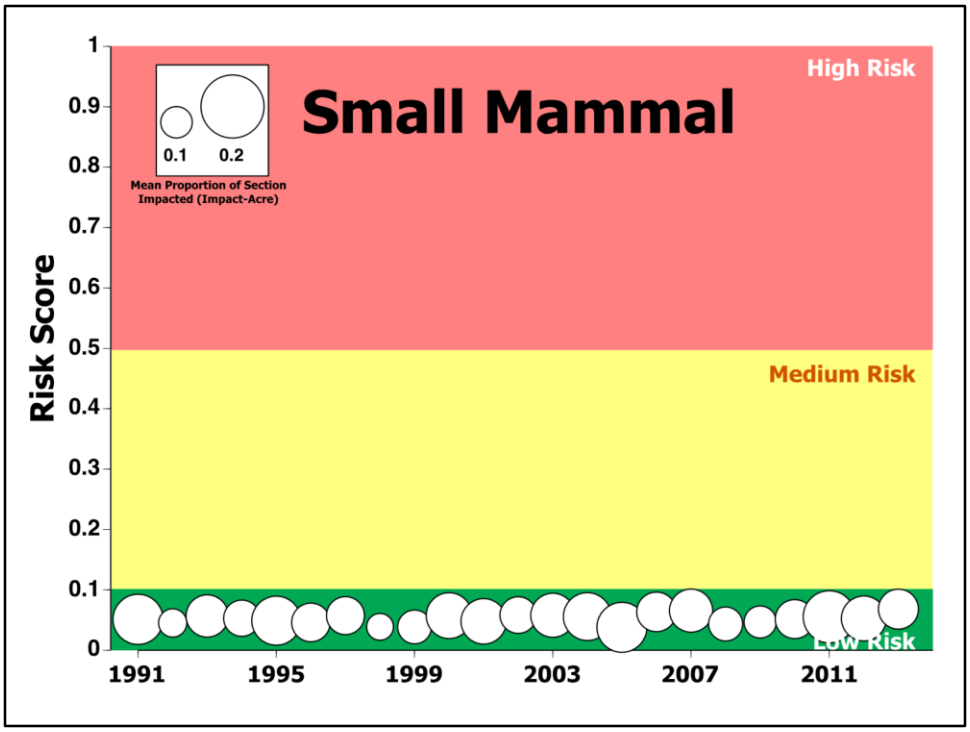
In these charts, the size of each bubble represents the "Impact Acres", the mean proportion of acres in a section impacted by the score shown on the Y-axis. Please note that the scale of these bubbles changes for different risk indexes. In this case a bubble the size on the left means that on average, 2% of each section was impacted by the mean risk score shown. On algae, the Impacted Acres is very small relative to a full section.



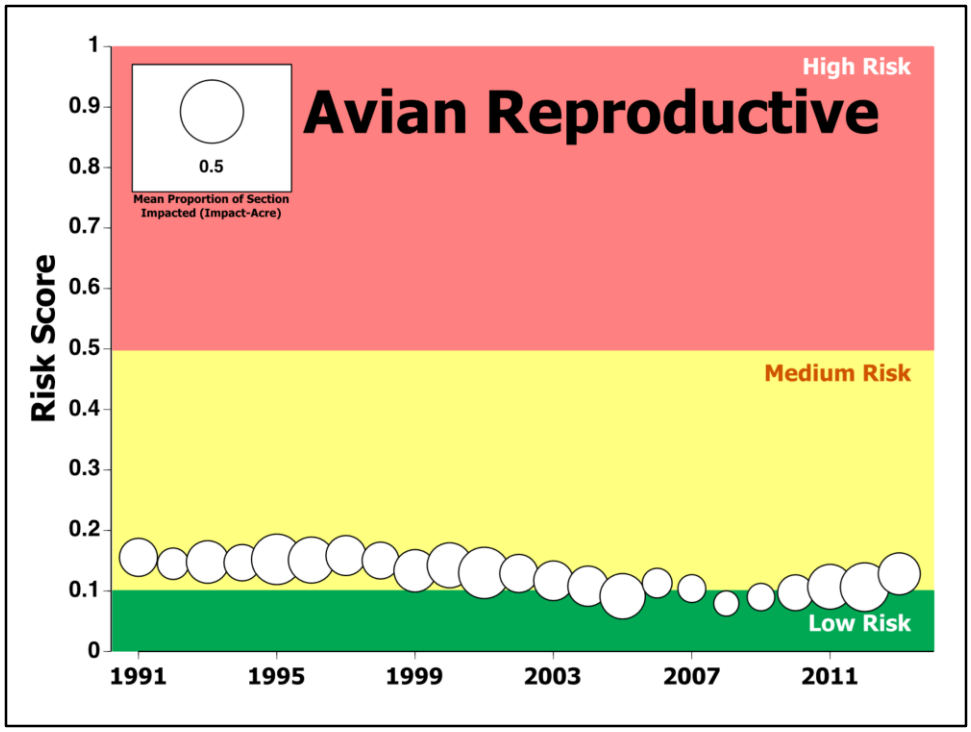
Fish Chronic risk index: Here both the scale and the bubbles are larger, indicating more acres impacted by the risk score means shown.



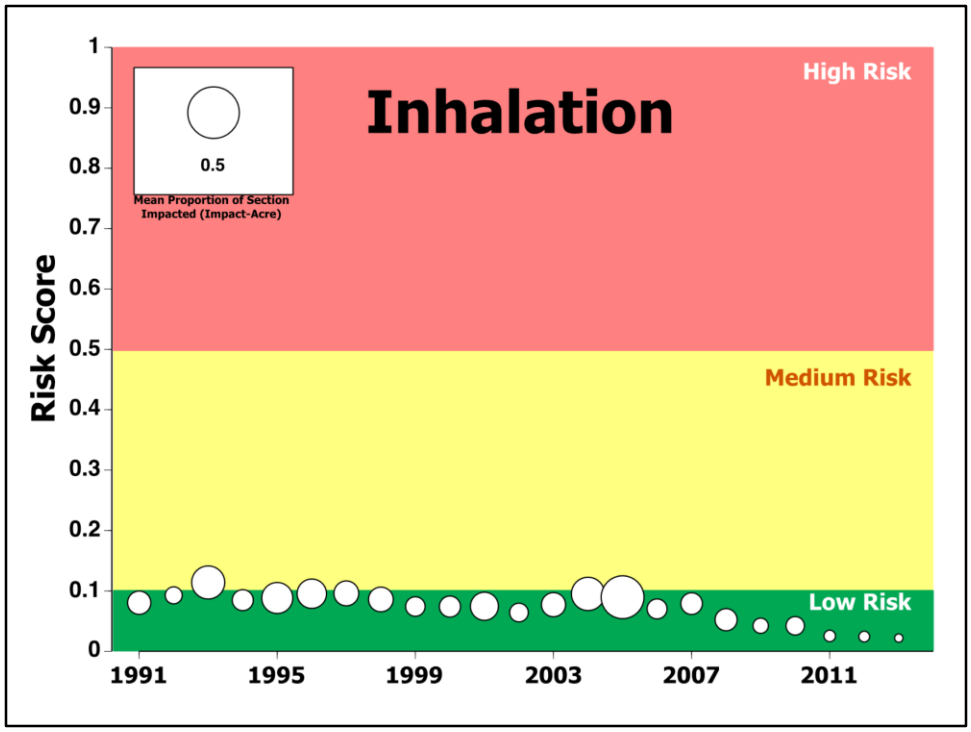
Avian Acute risk index



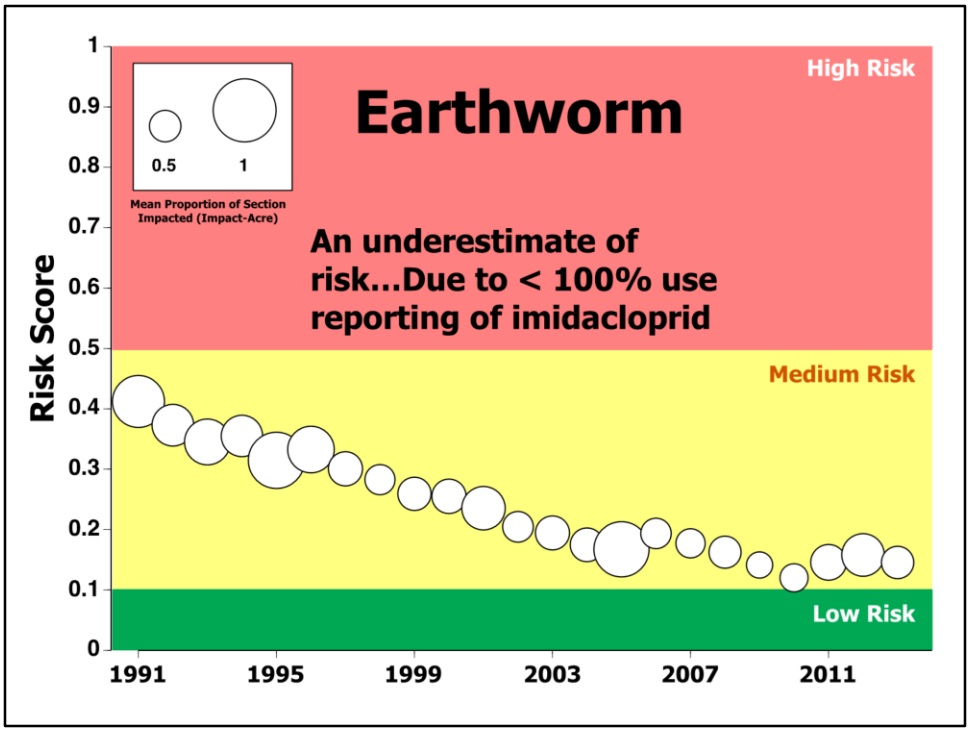
Small Mammal Acute risk index



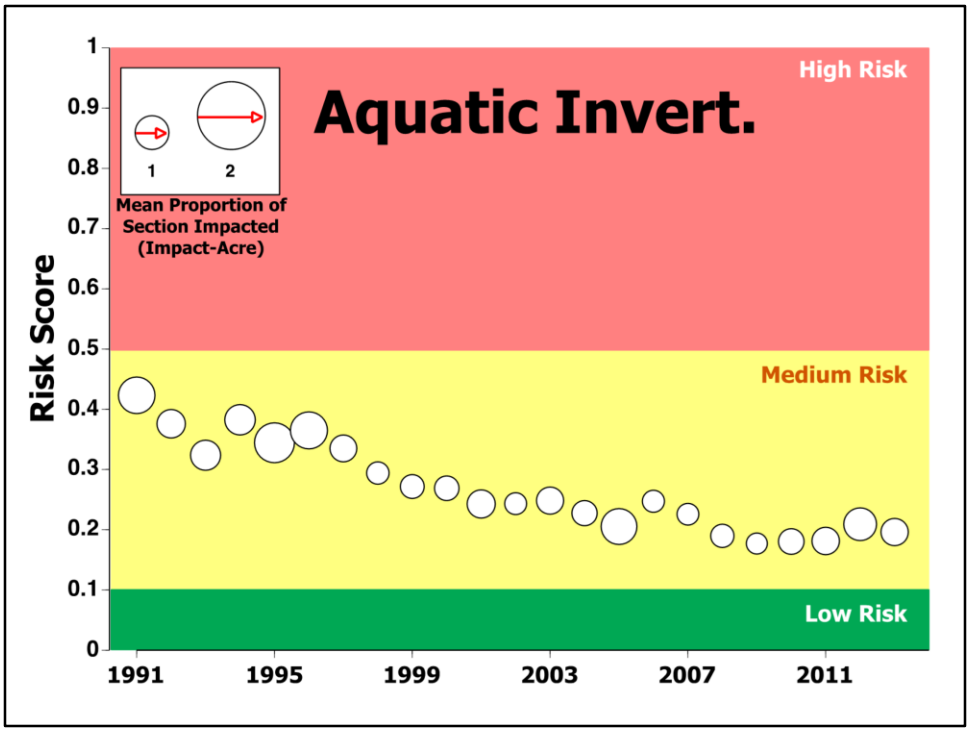
Avian Reproductive risk index



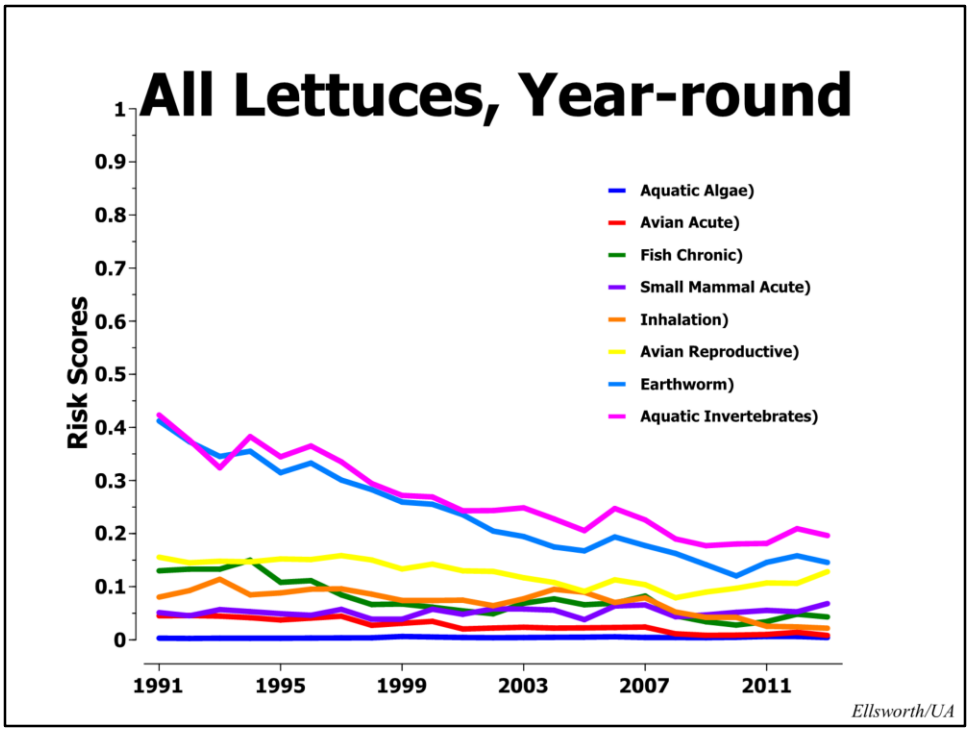
Inhalation risk index. (This is the only specifically Human index included in our analysis.)



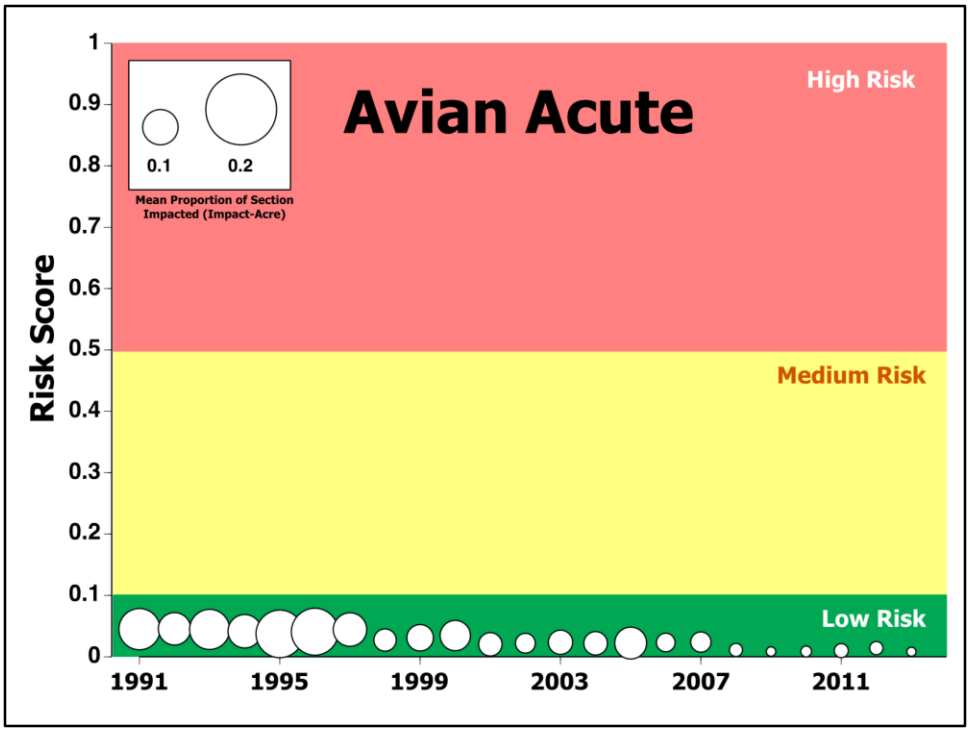
Earthworm risk index. (We know that impact acres are under-estimated here, based on under-reporting of soil applied imidacloprid, which we are aware from an independent annual survey of pest managers.



Aquatic Invertebrate risk. You see not only a declining risk, but it is affecting a smaller and smaller proportion of the lettuce acres. This during a period when lettuce acres were increasing year by year. So it really is a remarkable story.

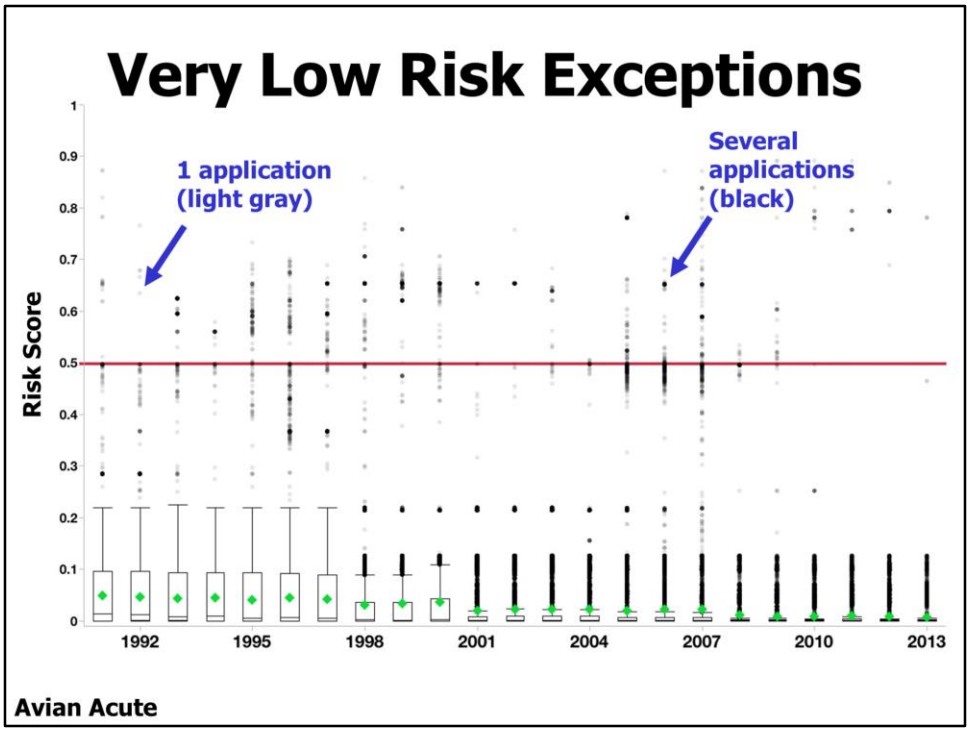


I will quickly show line charts of mean risk for the same data. These are for all lettuces, year-round combined.

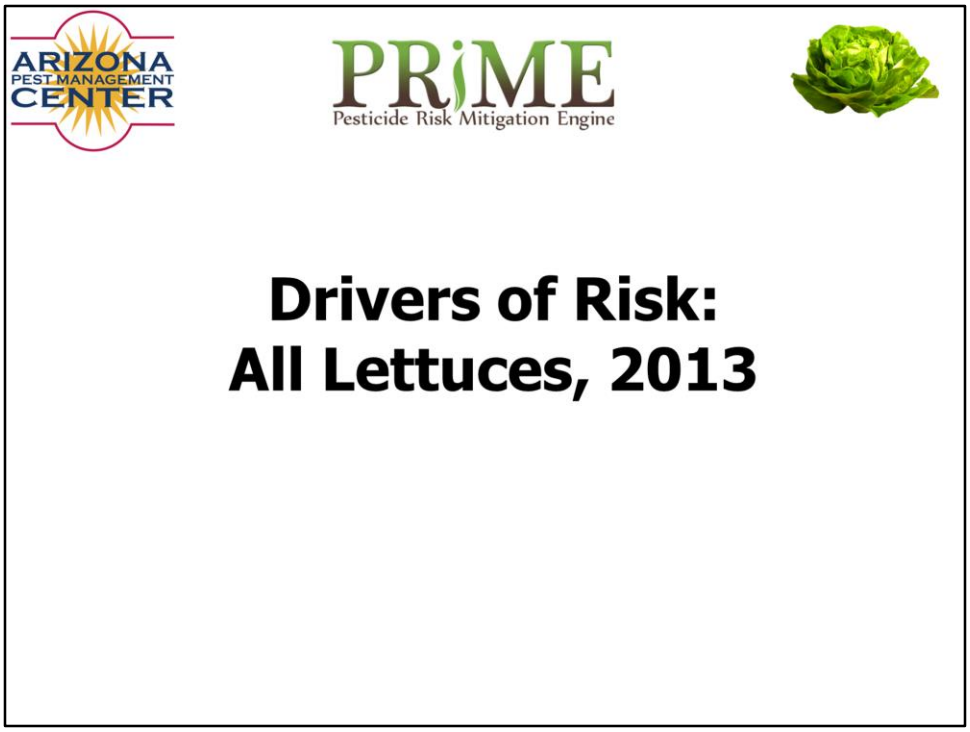


These overall low mean risk scores for all Active Ingredients do not mean that our IPM programs have eliminated all risk. In fact, even for those Indexes with low mean scores, there are typically many individual applications with higher risk scores.

So, for example, Avian Acute on our bubble chart shows that mean risk across AIs is very low throughout. But we can look at the distribution of all risk scores for individual applications to get a better picture of where higher risks are occurring.



On this chart, mean risk score is shown by the green diamonds. Risk scores associated with individual applications are now shown as a dots. Where these dots pile up on each other, they make darker circles, meaning more applications at that level of risk. Remember, everything over the red line is what we consider High Risk. Although Mean risk is low, individual applications still carry higher levels of risk. But you can see that the number of higher risk applications is greatly diminished in recent years.



We examined one year of data (2013) to see what chemistries are driving the remaining risk in the system.

What chemistries are driving remaining risk?

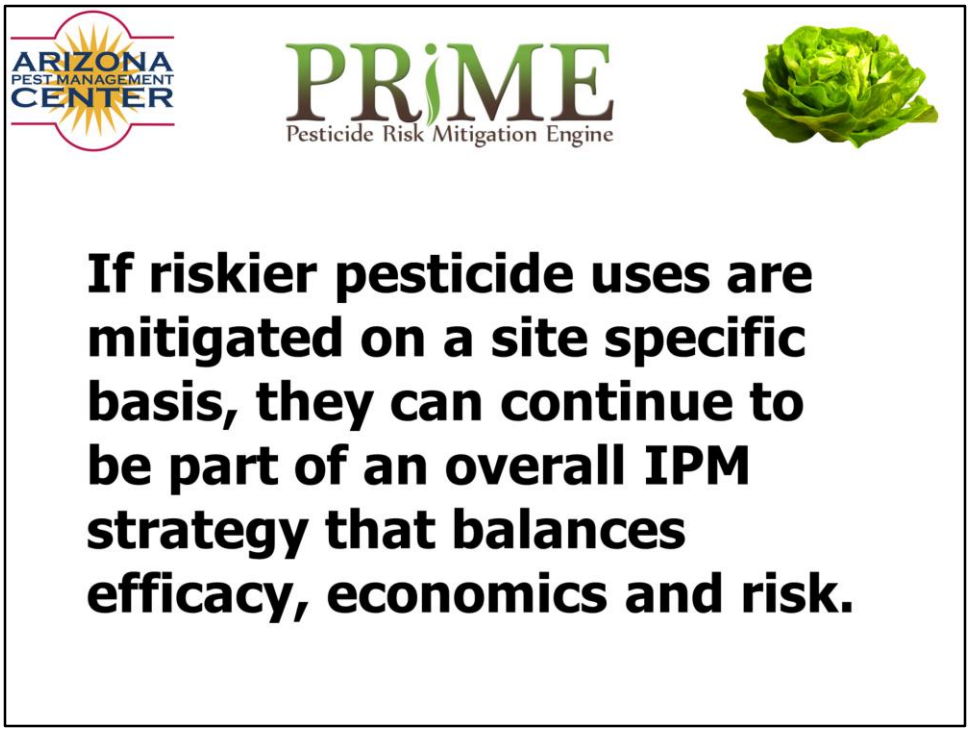
- Few drivers of risk remain
- In 2013, 17 AIs > 0.50 risk for at least 1 index:
  - 12 insecticides
  - 3 herbicides
  - 2 fungicides

Few "Drivers of Risk" remain in our system. 17 (out of 79) AIs applied to lettuce in 2013 had at least a few applications that resulted in greater than .5 Risk for at least 1 risk index. These included 12 insecticides, 3 herbicides and 2 fungicides.

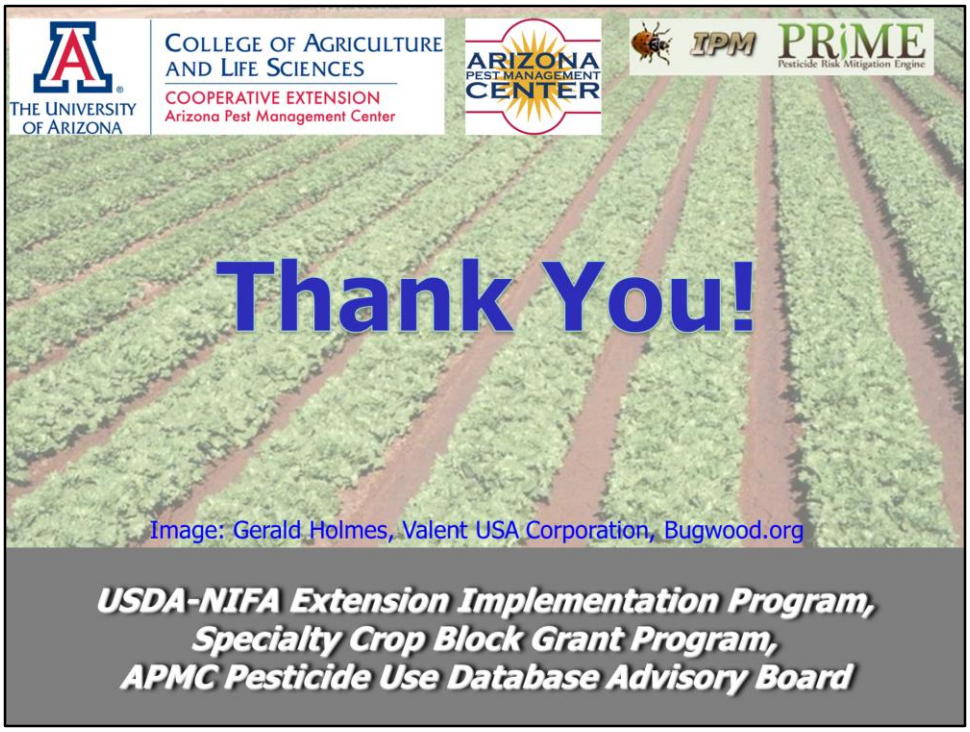
Risk Reduction Opportunities

A.I. (class)	Index	Mean Risk	Acres
BENSULIDE (OP)	Avian Rep. Sm. Mammal	0.9992 0.9918	29%
BIFENTHRIN (pyrethroid)	Aq. Invert. Earthworm	0.8745 0.6128	21%
ESFENVALERATE (pyrethroid)	Aq. Invert. Earthworm Fish Chronic	0.7063 0.7992 1.0000	11%
LAMBDA-CY. (Pyr.)	Aq. Invert.	0.5924	111%
PERMETHRIN (Pyr.)	Aq. Invert. Earthworm	0.6049 0.7798	40%
IMIDACLOPRID (neonicotinoid)	Aq. Invert. Earthworm	0.5757 0.9606	28%
PROPYZAMIDE (Amide)	Earthworm	0.6977	25%

This table highlights the most important remaining risk drivers, those impacting the highest percent of acres. For each AI, all Risk Indexes with >.5 mean risk are shown. Bensulide and Propyzamide are herbicides; the rest of these are insecticides. You can see the OPs (in green) and Pyrethroids (in gold) are still very important for some of indexes, both in terms of the risk scores and the percent of acres treated. Where risk exceeds 100%, for lamda-cyhalothin, that means on average there are more than 1 spray per acre.



We found that ipmPRIME provides an excellent tool to examine ecotox risk. This is important to IPM because If these riskier uses can be mitigated on a site specific basis, they can continue to be part of an overall IPM strategy that balances efficacy, economics, and risk.



Thank you for your attention and to Dow Agrosciences for making this scientific exchange possible. Thanks, too, to the many growers, pest control advisors and others who collaborate to make this such a successful program. I also thank my institution and institution of my collaborator (Naranjo), Univ. Arizona & USDA-ARS, ALARC, and numerous funding agencies that have supported our research and outreach over the years.

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