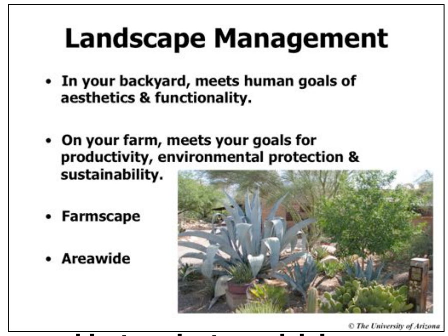
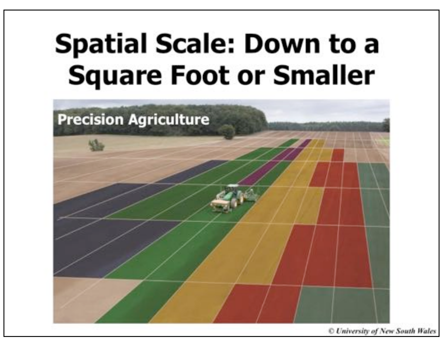
My name is Peter Ellsworth. I am an IPM Specialist, State IPM Coordinator, and Director of the Arizona Pest Management Center at the University of Arizona.

My topic today is about understanding the landscape influences on Lygus bugs in western agroecosystems for the purposes of managing Lygus in cotton.

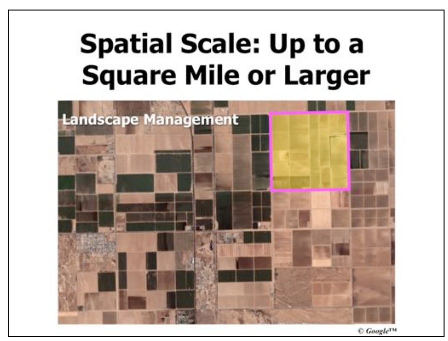


I want to spend just a minute explaining some terminology to reduce any potential confusion. When we say "landscape" management, some think about what happens in their backyard, as in "landscape plants." While this is not our usage of the term "landscape", there are parallels. In your backyard, there are human goals we seek to meet in the management of these plants. Similarly, on your farm, we have demands for productivity, sustainability, & environmental protection. Thus, landscape management on a farm or larger scale is about managing plants within the agroecosystem in order to meet our economic, environmental & social needs. Some people prefer the term "farm-scape"; others invoke "area-wide" as synonyms. However, we will define landscape to mean that area that includes regional variation in the plant & environmental community of interest, our agroecosystem.



As I see it, the next generation of farmers and pest managers will take advantage of major technological advances that encompass consideration of farming at two very different spatial scales. The first will and is operating at the dimension of the square foot or smaller in the form of all the advances being made in "precision agriculture". Growers will make decisions and have opportunities to efficiently manage inputs inch by inch.

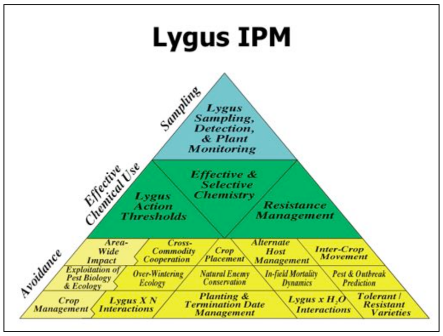
Image from: http://www.sage.unsw.edu.au/system/files/precision_farming.jpg



However, at the other end of the spatial scale, landscape management is pushing our frontier to dimensions of square miles or larger. By understanding complex ecological processes that operate on a larger, regional scale, growers as land-use managers will make many decisions that impact pest management on their farms.

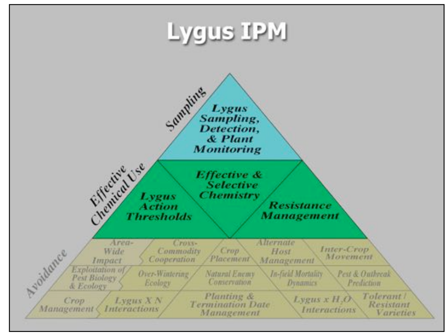
Considerations of these technological and knowledge advancements will increase grower's efficiencies in crop production and pest management.

The rest of my comments will focus on this spatial scale where we are attempting to develop understanding useful to landscape management of key cotton pests.

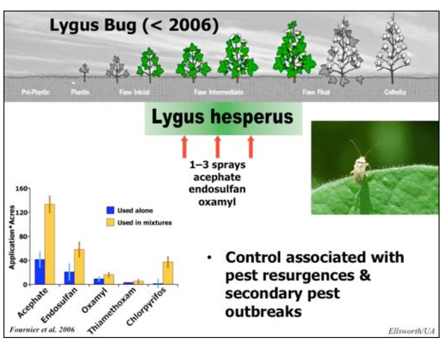


In Arizona, we depict our management system that targets Lygus in cotton this way, as a pyramid of interlocking and interrelated building blocks, the specifics of which may vary state to state or even farm by farm. However, the 3 basic keys of Sampling, Effective Chemical Use, and Avoidance should be common to any management plan for Lygus.

The foundation is in avoidance or prevention practices. However,…

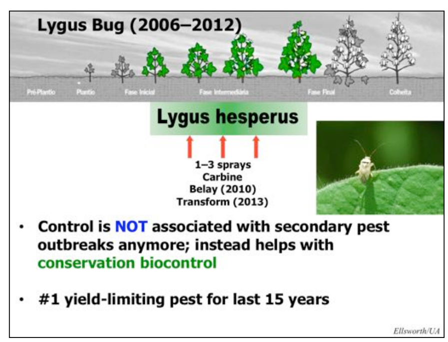


…Very often, our pest management industry focuses on the upper two keys to management, because these are common factors that are actively managed by professional, licensed pest control advisors (PCAs). However, the grower along with his/her PCA must consider the other resources and approaches that form the foundation of avoidance. Ignoring these major cultural, biological, and ecological tactics places undue pressure on the valuable chemical tactics in an unsustainable way, leading to resistance and other destabilizing impacts.



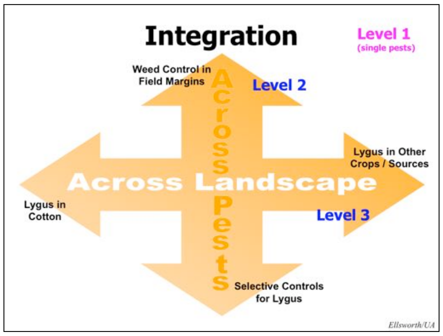
That said, let me briefly review the historical and recent status of chemical controls as they relate to Lygus management in Arizona.

Prior to 2006, this was the typical control pattern for Lygus in cotton in Arizona: when Lygus were present, growers made 1–3 sprays, on average, using very broad organophosphate, organochlorine, and carbamate chemistry. The result was often control of Lygus but with consequences for pest resurgence and secondary pest outbreaks. Despite the selective gains that Bt cotton and whitefly insect growth regulators (IGRs) provided us, these Lygus control practices destroyed our natural enemy populations, making us vulnerable to other pest losses.



Starting in 2006, our entire cotton IPM system was once again revolutionized, largely because of a key change in Lygus management. We still make, on average when needed, 1–3 sprays against Lygus. But now, we used flonicamid (Carbine) that is fully selective and safe to beneficials. Belay (clothianidin) was registered in 2010 and was the first neonicotinoid to give significant efficacy against *Lygus hesperus*. When rates are managed properly, some safety to beneficials is also possible. In 2013, we now have another very selective and effective compound, sulfoxaflor (Transform), in Arizona cotton.

More importantly, with fully selective products (Carbine or Transform), control is no longer associated with secondary pest outbreaks & conservation biological control is further enabled.



Integration is key to IPM! Integration & IPM operate at different levels of complexity as part of a continuum. The most basic level of IPM is the consideration and use of multiple tactics to control an individual pest group. That's Level 1. But integration can be thought of in at least two more dimensions: across the pest spectrum for a given crop or location like controlling weeds and Lygus in cotton. That's multi-pest and that's the second level of IPM (Level 2). But we can also integrate across the landscape incorporating all the crop and non-crop resources within, i.e., multi-crop or multi-site. This is a very complex level of IPM or Level 3 integration, and is largely aspirational. However, with new advances in understanding landscape level systems, we should be able to manage Lygus and other pests at this level of integration.

Our controls should be integrated as well, e.g., chemical, biological & cultural controls. So what is cultural control?

Agri-culture like many of our words has its origins from Latin. Agri- (or ager in Latin) as in agricola, which means farmer in Latin, literally means "field" or "land". However, "culture" comes from the Latin verb "colo" to till or to tend. So Agriculture is the tending or tilling of fields.

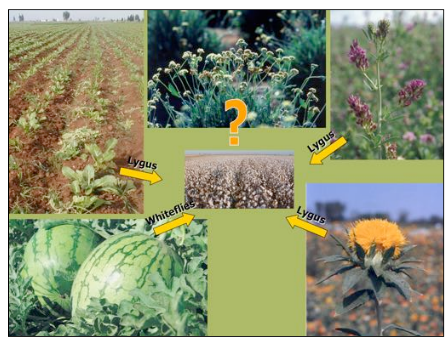
Cultural <u>practices</u> help growers meet production goals. Cultural <u>controls</u> help growers and others reduce pest populations or their damage through some deliberate manipulation of the production system.

Landscape management is, as you will see, an important cultural control.

One major, deliberate alteration of the production system is in the very crops planted into our agroecosystem.

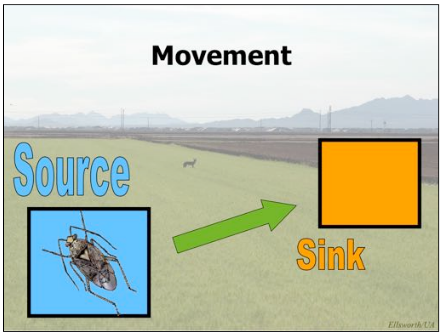
For decades, growers and scientists have made important observations about the relationship between crops in a system. Many have noted that if you are close to a source, your risk of invasion is greater. Around the cotton belt, we see examples where bollworms/budworms can be sourced from corn, sorghum, and peanuts; stink bugs from soybeans, peanuts, and wheat; and thrips and mites from wheat and corn, respectively.

But over what scale does this occur? Just from adjacent fields? From miles away? In most cases, we just don't know without specific research.



Likewise in Western landscapes, people have seen whiteflies sourced from watermelons and melons, and Lygus sourced from sugar beets, alfalfa and safflower.

But what about new crops introduced into a region like guayule. When we started our landscape ecology project, guayule was under development for commercial production. Growers often are pre-occupied by commercial markets & the costs & value of production. But we should also be asking, is this new crop a source or sink for Lygus? We knew that Lygus can feed on this plant like dozens others.



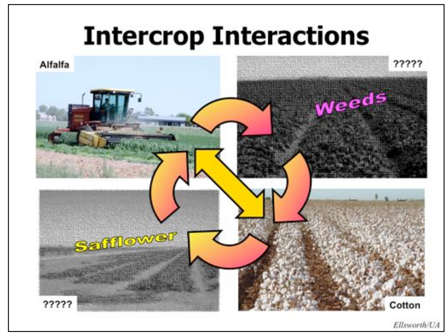
So what is a source and what is a sink for Lygus?

Insect pests and beneficials arrive to and depart from grower fields each year. Where they come from are "Sources". Where they go are "Sinks".

That's the simple definition. But it is important to recognize that when we measure these effects (sources & sinks), we are measuring the ecological results of movement and reproduction.

We conducted research in a 5-yr project (2006–2011) that helps us precisely define what the source and sink habitats are and how we can manipulate them for the benefit of the entire community.

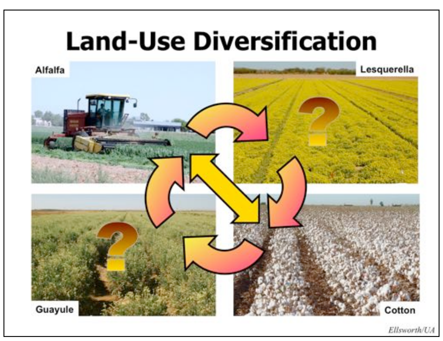
Since Lygus do not overwinter in cotton, understanding source crops is central to landscape management and to cultural control.



We already knew some things about how Lygus use and move from different hosts. E.g., alfalfa grown for hay is alternately a source and a sink for Lygus depending on cutting status.

Other relationships have been noted in our desert ecosystem including winter weeds brought on by El Niño influenced winter moisture that host Lygus; or when safflower is planted, growers have long known that cotton immediately adjacent to this releasing source host is going to be damaged by Lygus.

Damage to or protection of cotton is completely dependent on the proximity of the source or sink. But until recently, we just did not know enough to reliably advise growers, plus our landscape may also be changing…



Land-use diversification is leading to brand new relationships representing new risks as well as new opportunities. After all, we want producers growing money (and not necessarily just cotton) and as markets change, crop mix will change including at times the introduction of new crops like Lesquerella and Guayule, both of which host Lygus. However, we did not know how these changes would impact Lygus movements and distribution. Some land-use changes might improve our ability to manage Lygus; others might make things worse.

Guayule is summer flowering perennial that is commercialized and expanding; it does host Lygus. Lesquerella remains an experimental, early spring flowering crop that does host large reproducing populations of Lygus, just like other members of the mustard family.

As part of a very large cooperative USDA-Risk Avoidance and Mitigation Program team, a group of us wished to advance our understanding of Lygus movement and management across the entire agroecosystem of the West and integrate that with existing IPM programs. Together with:

Pete Goodell, UC-IPM

Yves Carriere, Univ. Arizona

Christa Kirk, Univ. Arizona

Russell Tronstad, Univ. Arizona

Megha Parajulee, Texas AgriLife

Stan Carrol, Texas AgriLife

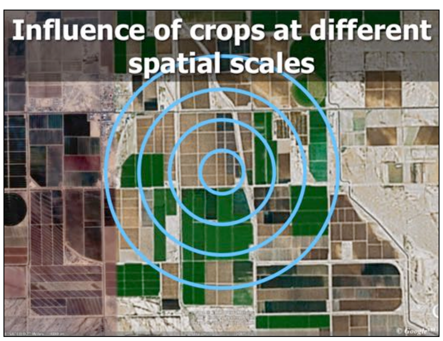
I was involved in the conduct of a 3-state, regional ecology project for development of landscape level management strategies for Lygus.

We should not forget that abundance is affected by both Field-level processes, and a set of Broad-Scale processes. While there is not much we can do about the weather, a grower does control Local Management decisions on his/her own field or farm and the larger goal was to continue to develop research to support this decision-making.

However, insect abundance is also affected by one Broad-Scale Feature that we can control, host or crop and non-crop distributions in an area. It is these opportunities, both "great" and "small" in scale, that we wish to exploit for the benefit of agricultural pest management.

So we developed an approach using new mapping, computer and analytical technologies that help us advise growers how to minimize damaging Lygus populations through crop placement.

We did regional sampling for Lygus that followed these steps…

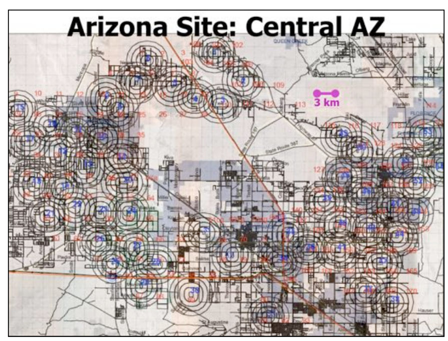


This large study was focused on this question. How is the cotton field in the center of these rings impacted by the cropping diversity in the rings that surround it?

The ring analysis permitted us to infer the relative influences of crops as sources or sinks for Lygus over different spatial scales.

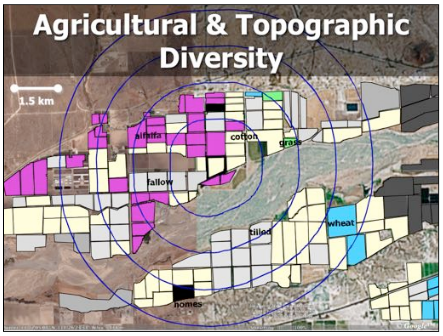
With this analysis, we no longer have to "guess" about how far is far enough from a source crop, or alternatively how close is close enough to a protective sink crop for Lygus management.

2007FF#27



This was our experimental area in one of the 3 states, nearly all of Pinal County, AZ! Each set of rings surrounds a cotton focal field in which we took detailed measurements of Lygus numbers from grower fields. We also measured crop diversity and location across a 3 km radius of each focal field and collected information on what sprays were made and crop flowering. We sampled about 55 fields for each of 3 years, 2007–2009.

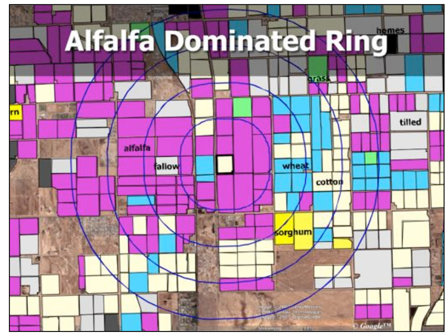
The following are the type of scenes we were seeing in our AZ agroecosystem…



Arizona is both agriculturally and topographically diverse. So we looked at many situations so that we can compare them and identify the best arrangements for crops.

Alfalfa (in purple) is a consistent element of our system. Cotton is in light yellow, fallow and tilled ground are colored gray, wheat is light blue, and homes and other buildings are black. Each ring or donut depicted here represents a 0.75km slice progressively out to 3km around the field (or about a max. of 2 miles).

By examining Lygus densities in the focal fields and relating this to densities of different habitats in each successive ring, we can geostatistically correlate the rise and fall of bug densities with specific arrangements of surrounding habitat. When the correlation is strong and significant, there is a relationship we might be able to exploit. **2007 FF#53**



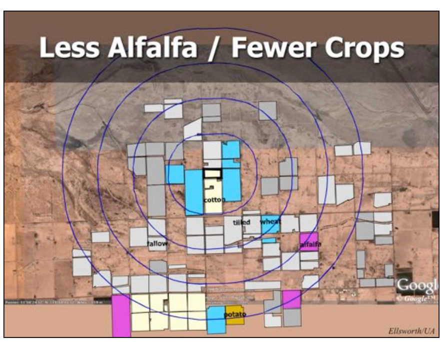
In this example, alfalfa dominates the landscape around the focal cotton field and throughout the 3km area.

Is this a situation that protects or harms cotton with respect to risk of Lygus colonization and damage there?

By examining the donut slices, we can estimate how far these relationships extend, whatever they are.

Between the AZ and CA sites, we found that alfalfa grown as a forage, i.e., subject to regular cuttings, most often served as a source for Lygus.

2007 FF#47

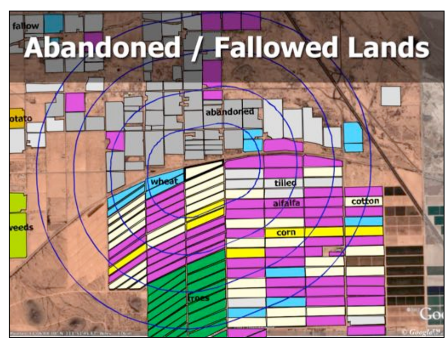


Here is an example with less alfalfa and just fewer crops overall. There is a lot of idle land here.

Is this a risky scenario?

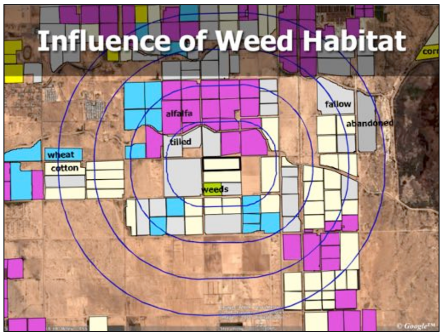
This depends on the condition of the uncultivated land. In general, uncultivated lands act as sinks probably by the mere fact that Lygus have to travel greater distances to reach cotton. However…

2007 FF#06



Here is another example where there is abandoned land that is slowly reverting back to native desert, a process that takes decades.

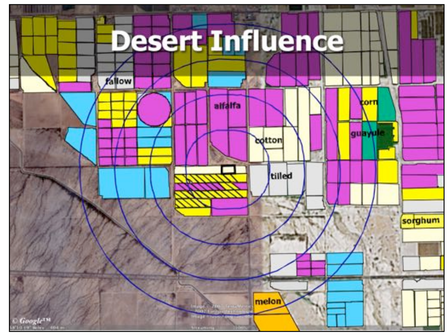
2007 Focal field #05.



Some fallowed lands developed into significant summer weed habitat nearby our focal cotton field. The result was this area of weed habitat served as a short range source for Lygus.

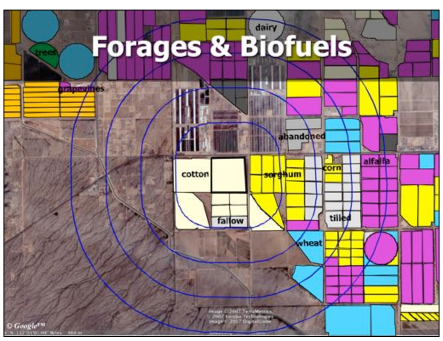
So anywhere there is a broken ditch, tailwater or other uncontrolled movement of water, we can see significant weed habitat develop that may later dry up and source Lygus to cotton.

2007 FF#42



Of course the desert influence is of interest to us as well. In some years, winter rains can feed spring weeds and other blooming plants that paint the desert yellow, purple and gold. Lygus can thrive in years like this and depending on the period of dry down can funnel Lygus directly to cotton or more usually to some other bridging cultivated host like alfalfa.

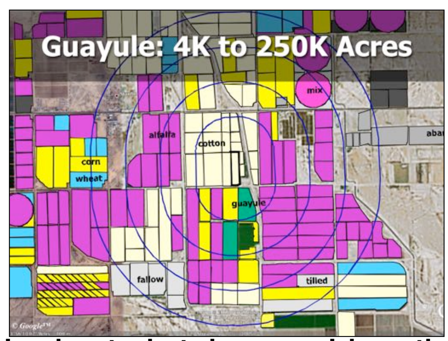
2007FF26



As the U.S. policy on renewable energy changes, local interests in forages and biofuels may ebb and flow. In Arizona, We have more demand by dairies and by biofuel refineries than at any other time in history. As a result we have more corn, sorghum and alfalfa than at any other time. Similar regional changes have been occurring throughout the southern cotton belt. The consequences for insect movement and source/sink relationships is far-reaching.

How will these land-use changes affect Lygus broad-scale dynamics?

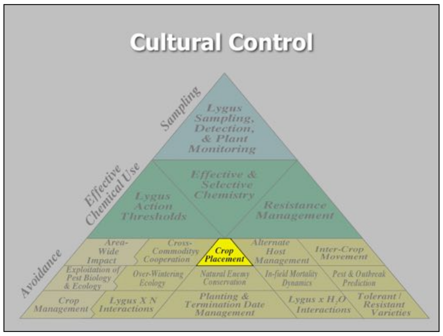
In Arizona or the other sites (TX/CA) of this study, we did not measure any significant effects of corn or sorghum on Lygus source/sink relationships with cotton.



Guayule is a desert-adapted, commercial crop that may expand, with a projected western acreage of 250,000 A one day spanning W. TX to the San Joaquin Valley, CA. It is grown as a perennial and is a known reproductive host for Lygus. It was grown on about 4,000 A in AZ in 2007.

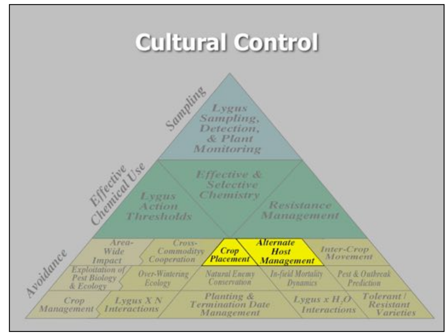
But have we considered what the addition of this crop resource will have on pest management generally? Or, on a pest areawide? We know that Lygus feed on and reproduce in guayule. We also know that there is little measurable damage to the plant by this insect (so much like with alfalfa, the guayule grower is unlikely to spray this potential cotton pest).

We did not have a lot of areas where we could test the influence of guayule; however, when we found an effect, it was serving as a sink for Lygus, sopping them up like a sponge from nearby habitat & protecting cotton, though usually over only a short range. 2007FF#27

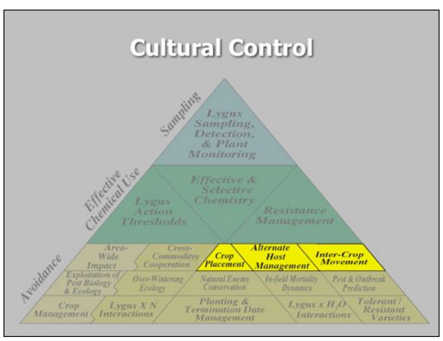


Returning to our Lygus IPM pyramid, we find "Crop Placement" right at the heart of our IPM strategy. Crop placement is central to its availability to pests. By strategically considering how we arrange and place our crops both in space and time, we can help to deny our crops as a resource for pest insects.

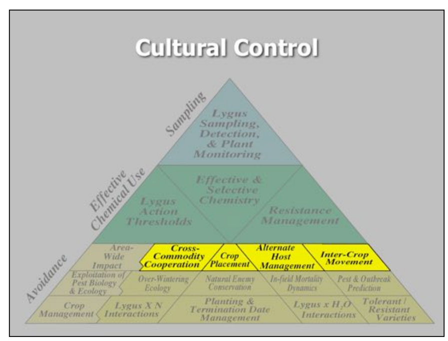
The problem until now is that we have had only very limited information on how to strategically arrange our crops to prevent or minimize damage from insect pests.



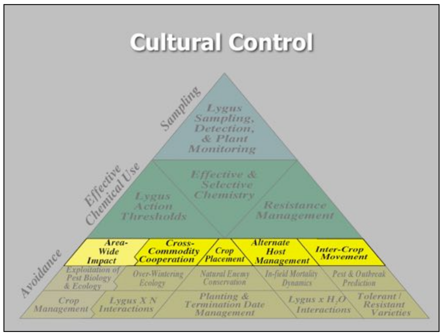
But by arranging crops, we can effectively help in source reduction and "alternate host management", another key building block of IPM, also known as source reduction.



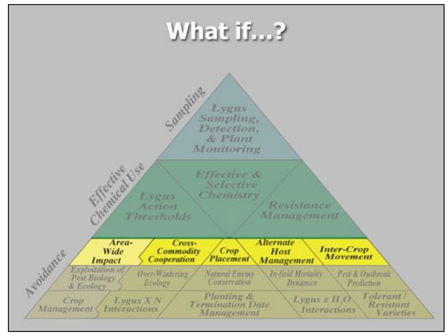
Which capitalizes on the knowledge we've gained in predicting Lygus inter-crop movement.



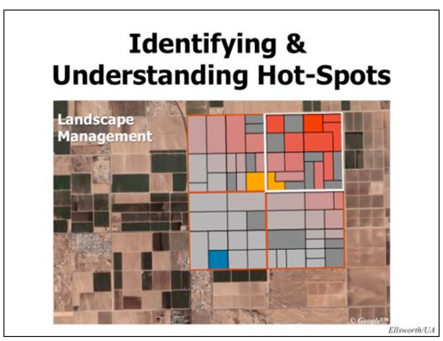
And, hopefully through even a minimum dialog with our neighbors, cross-commodity cooperation can further leverage management power.



Taken together, each of these cultural practices permits us to contribute to an overall area-wide impact on Lygus populations, lowering the risk to individual growers and for the entire community.



What if we knew enough about the spatial ecology of Lygus in a system that we could re-organize crop resources to minimize risks of Lygus infestation? And, if we could, is it possible to maximize individual as well as community-wide economic gains?



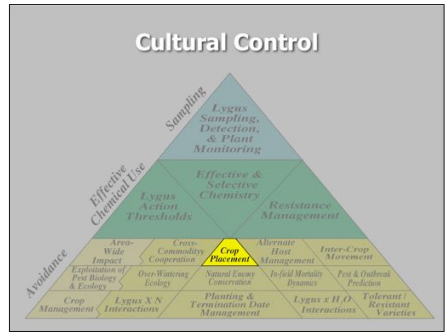
If a grower knew going into their planting season that, structurally, they were designing a situation that would produce areas with unacceptably high risks for damaging Lygus populations, would they re-think the arrangement of crops on their land?

A "cotton" grower is almost never a grower of just cotton. Virtually all farmers select from a palette of crops that are adapted to their region and for which there are markets to sell their production. These are some common ones available to the average AZ "cotton" grower.

Guayule is an interesting sideline and case study. Here is a new crop! A good thing for most growers as it provides production alternatives. An even better thing for cotton growers, because it serves as a summer sink for Lygus helping to prevent movement into cotton. And, it is not damaged by Lygus!

But what have we forgotten? A key cultural control tactic is rotation of crop plants to prevent build up of harmful plant pathogens (diseases), nematodes, weeds and other pests in the soil. In order to make this work, farmers have to lay out some ground, i.e., not plant anything, keep it fallow.

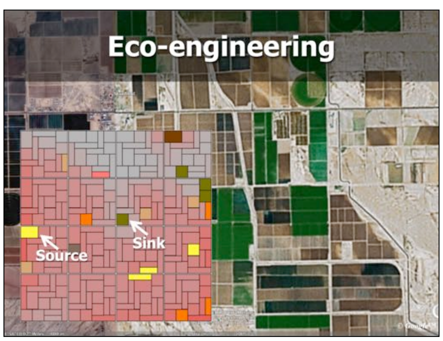
While this may not seem like a resource for Lygus one way or the other, fallow land does serve as a spacer between sources and sinks (cotton). With large enough lands left uncultivated and weed-free, it may be possible to create distance between cotton and Lygus source crops. Our studies showed that in CA, uncultivated habitat could function as a "sink" for Lygus up to 1km from cotton.



Before now, our recommendations in this basic cultural control have been very generic. Avoid planting "near" sources of pests. This study has shown us that it may be possible to manipulate crop placement over an area to minimize risks of pest damage by Lygus.

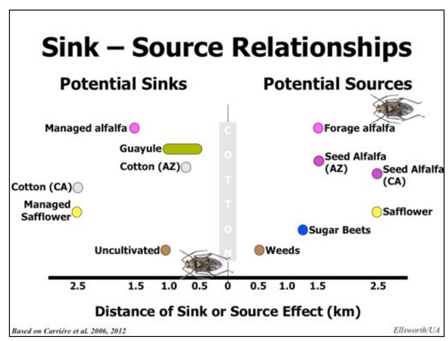
But with so much going on simultaneously, what resources does one need to learn and understand the best configuration for managing Lygus risk?

To help with this challenge, we developed a simulation that operates in a multi-user (grower) environment, where growers plant crops from a palette and the simulation maps out risk of Lygus infestation and economic loss as a heat map.



Ultimately this is a where IPM is headed in the future, and is a form of eco-engineering where we attempt to "build-out" pests by manipulating the arrangement of crops that source pests and sensitive sink crops that receive and are damaged by pests. This is depicted here in a "heat" map that shows the intensity of Lygus infestation across a landscape as shades of pink over gray cotton fields. For example, yellow represents a source safflower fields and green fields are guayule sinks.

Our simulations allow us to examine complex patterns and outcomes over and over again as virtual years.



These are the sink-source relationships that we have detected in the West, showing our cotton resource of interest, the one we wish to protect from Lygus, in the center of this chart. A potential source is a crop relationship that shows net increased movement toward or accumulation of Lygus in our subject cotton field. A potential sink is a crop that attracts a net movement or accumulation of Lygus away from our subject cotton field.

Forage alfalfa ~ 1.5 km source; Seed alfalfa in AZ about the same, but a longer range source in CA (2.5km); Safflower ~ 2.5 km; Sugar beets 1.25km; Weeds ~ 0.5km. Sinks include guayule ~ 0.5–1km; Cotton in AZ ~ 0.75km; Cotton in CA ~ 2.5km; Uncultivated (weed-free) fields ~ 1km.

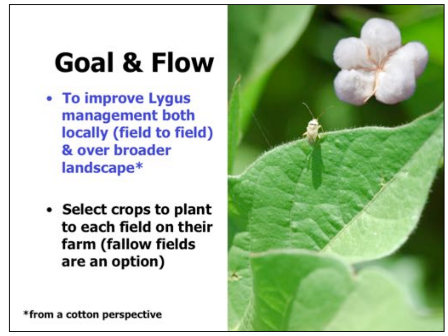
Safflower & forage alfalfa reverse function from source to sink if they are managed for Lygus.

So what does that mean to manage these insensitive crops for Lygus, crops that are not normally damaged by Lygus?

For forage alfalfa, this means adopting a summer practice of strip harvesting or leaving remnant strips of uncut alfalfa that will help retain Lygus and prevent their movement to other fields including cotton.

For safflower, Lygus developmental models were produced in the 1970's by California researchers that showed that one timely and effective spray to safflower before Lygus developed into adults and before safflower was dried down forcing adult movement out effectively prevented the normal mass migration.

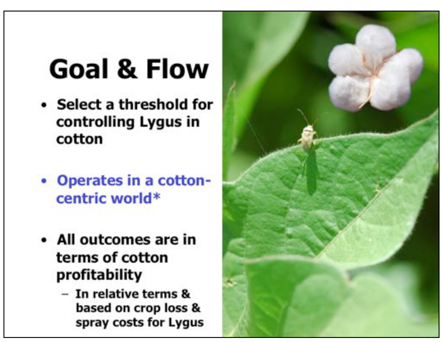
As a results, these crops can function effectively as protective sinks for Lygus management in cotton.



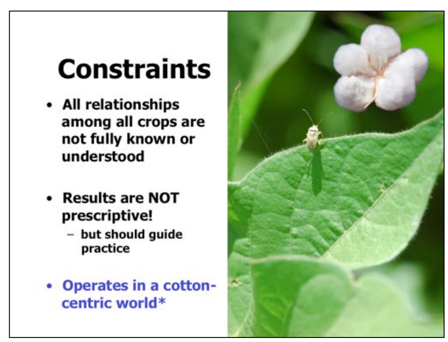
Our multi-user simulation is deployed in grower workshops where the goal is this…

Our flow depends on each farmer managing their own farm (a section in size), where he/she selects and plants crops where they prefer.

Opportunity exists to select a Lygus threshold, I.e., the level of Lygus you tolerate before spraying.



Key to our simplified view of this virtual farmscape is understanding that we have designed it around protecting cotton. Our goal is to optimize outcomes for cotton, not all the other crops in the system. We should note that in our systems, cotton is the most sensitive to Lygus damage. So this simplification is not unrealistic.



The exercise shows us the general patterns of Lygus movement and damage that we should expect, but is not prescriptive, in part, because not all relationships among crop and non-crop resources are known. However, great insight is gained in how we can manage all of our crop resources, in this case, to be protective of cotton from risks of Lygus damage.

The simulation does represent a cotton-centric world.

The game still needs some adjustments and improvements. We have not widely deployed it yet in grower settings. We have conducted a number of farmer and other focal sessions to better hone its deployment.

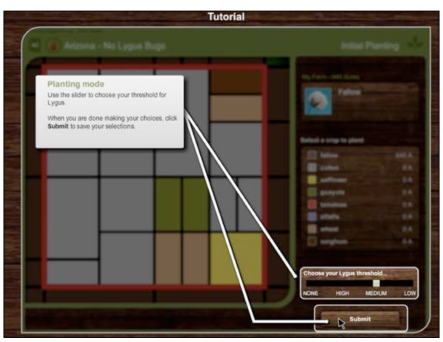
There are settings that can be made to each session to better represent the local crop ecology of those participating in the simulation. As we learn even more about crop and non-crop resources for Lygus, we can add this information to the simulation.

The simulation accommodates up to 16 different farmers over an area, when simulating AZ fields, represents a typical ~10,000 acre valley or community of growers.

Progress is tracked in %yield loss & minimizing economic losses on a per acre basis; all for cotton only.

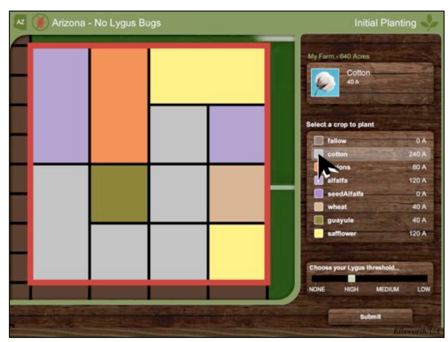
We won't play out the simulation here, but I will share with you some elements of this simulation and some typical outcomes.

Here we show a screenshot from the tutorial that shows a planting palette of 8 "crops" that individual growers can plant onto their land holdings.



During some points in the simulation, the grower can select a high, medium, or low threshold for Lygus, with the medium one representing the Cooperative Extension guideline for the region. It is also possible to elect not to ever spray for Lygus.

Again, this setting only pertains to cotton.



Here is a growers farm, 1 mile x 1 mile, showing planting of cotton, melons, safflower, forage alfalfa, wheat, and guayule. Note the summary of acreages to the right and threshold setting as a high threshold, meaning the grower can tolerate higher numbers before spraying.

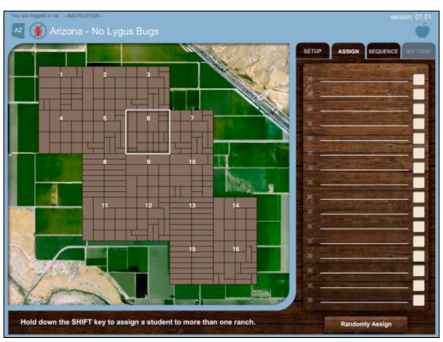
There are no constraints on planting at all, except for this to be a cotton exercise a farmer must plant at least one cotton field.

The planting palette can be changed to reflect different cropping choices, even including "managed" alfalfa (strip-cut) and/or "managed" safflower or safflower that acts more like a sprayed trap crop or sink.

In an initial run without "bugs" introduced to the system, farmers are shown their losses and net profits, which max out at $100 / A. These do not reflect market prices and costs of production. This is a scale relative to a maximum profitability of $100 / A.

In these early runs, a grower can only see his own farm and is also not knowledgeable about what is being planted by his/her neighbors.

There are 3 landscapes (CA, AZ, TX) that can be deployed including this one for Texas where there are center pivots and both irrigated and non-irrigated fields, including the dry corners of square fields that encompass the center pivots.



This is a typical AZ landscape or farming community. The geometries do not literally mimic any one community, but the arrangements and sizes/shapes of fields are from actual farmer fields in AZ.

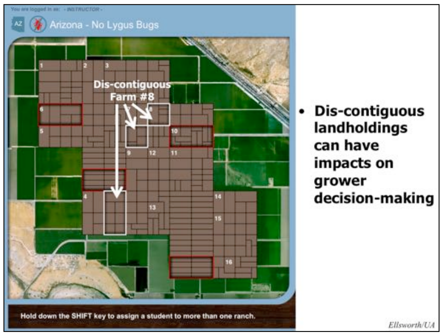
The white outlined area is one "farm", a section in size which is one mile on each side and encompasses 640 A.

The basic game assumes that a farmer's landholdings are all contiguous as shown in the previous slide. This has consequences for decision-making for crop placement.

However, in AZ it would be unusual for a farmer to have all his/her holdings in just one location. So we have a dis-contiguous deployment of our game that separates their holdings into 1, 2 or 3 locations across the landscape. Sometimes these holding are close together, sometimes more distant.

This can have dramatic impacts on game play.

Here is a farm (white outline) with two locations (2 half sections). Again, to start with, the grower would not see the entire community planted, but just his own land holdings.



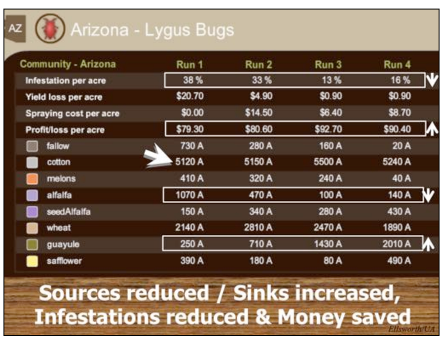
Here is one with 3 locations (white outline) and 2 with 2 locations (red outline).

The impact of these configurations on grower decision-making can be profound. For instance, if you are a cotton and safflower grower, your individual interests might be served by aggregating all your safflower on one part of your farm distant from any of your cotton that is planted in an entirely different location. But the consequences for your neighbors near your safflower may be catastrophic.

At anytime during play, we can deploy a "score sheet" of sorts that tells the individual how well they have done individually and as an entire farming community.

It contains information like %infestation over time.

This shows 5 runs where infestations went down progressively over time because of deployment of "smarter" planting patterns.



Economic profit per acre, and change in size (acreage) of their crops over multiple runs.

Here is an interesting set of runs where the Community saw progressive declines in infestation levels and generally increasing profitability. This was accomplished in this case by reducing alfalfa acreage (a source for Lygus, if the crop is not managed) and by increasing guayule acreage.

All this was accomplished while still about half of the community (5000 A) was planted to cotton.

While some of these crop shifts may be extreme, this does illustrate that growers are "in control" of the landscape dynamics and there is potential for individuals and groups to manage Lygus regionally.

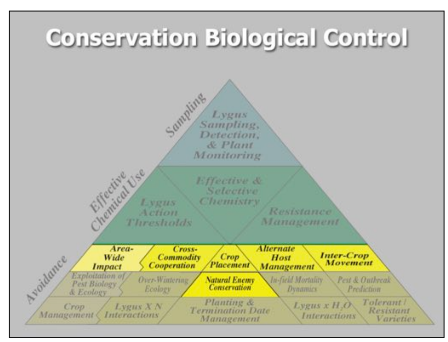
Here is what that community looked like at the start, a typical community with 5000 A of cotton, about half the land mass. Some yellow safflower (350A) scattered about, purple forage alfalfa (1070A), and cotton infestations averaging 38% with losses of nearly $21/A.

This heat map shows the extent and intensity of Lygus infestation, in cotton only, and the distribution of sources (in orange) and sinks (in teal).

A re-arrangement of the community to include many more teal "sinks", in this case guayule, and fewer sources, drastically lowers the infestation as shown by lighter shades of pink or even entirely gray-colored (no infestation) cotton fields in this heat map.

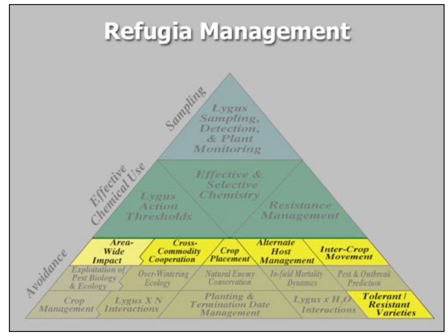
The cotton acreage did not change between these two runs.

We gained valuable new insights into Lygus movement & landscape management. We've identified key host plants that serve as sources like seed alfalfa and weeds; we've identified some novel sinks for Lygus like guayule; & we've identified some crops that can serve as sources or sinks depending on whether they are actively managed for Lygus movement like forage alfalfa or safflower. Importantly, we've learned a lot about the scale of these movements. We know for instance that some crop to crop relationships operate over short ranges as little as 500m & others over much longer ranges, as much as 2.5 km. We developed a simulation that provides growers with virtual farms for strategic planting decisions so that they can see the many interactions that occur over typical farming communities. Best of all, this gives us hope that we can improve individual and community outcomes without necessarily spending any more on controls, but instead just more strategically choosing and arranging crops so as to minimize the negative impacts of Lygus movement.

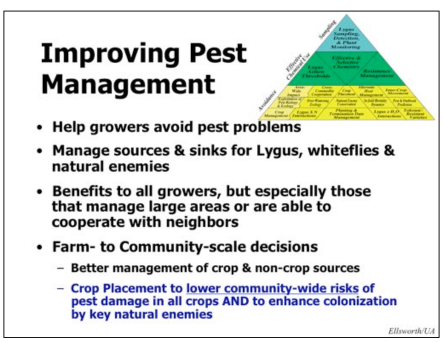


In the future, we hope to develop these large datasets so that we can understand natural enemy (beneficial insect) movement across landscapes and use this simulation platform to teach growers about how to develop sources of NEs for their system and not just how to prevent Lygus movement to cotton.

This platform is ideal for addressing any spatial aspect of agriculture. Resistance management or gene flow of resistance genes or refugia management are all ripe for this kind of an approach. We envision developing modules for these situations as science and new data are developed for these systems.



For example, refugia management or even deployment of resistant varietals within a system could be modeled and played out in this simulation in the future.



To summarize, our goal is to help growers avoid damaging Lygus populations right from the start. We hope to do this by giving them specific advice on how to manage the plantings of their many crops. By knowing what crop placements lead to more "sinks" for Lygus than "sources", a grower can become more profitable while reducing risks to the human health and the environment.

Any grower or entity who controls a larger region will benefit the most because they control a larger part of the landscape. But through even limited cooperation, even smaller farms can benefit from strategic planting practices, and clearly the whole community can benefit as a result.

Thank you for your attention.

Thanks, too, to the many growers, pest control advisors and others who have already collaborated with us and allowed us into their fields and provided pesticide records for this project.

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

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