Integrated Pest Management: Strategies for Pollinator Habitat Promotion and Conservation in Agricultural Areas

Speakers: Dr. Allan Felsot,
Professor at Washington State University;
& Khue Nguyen, Environmental Protection Agency

Transcription provided by:
Caption First, Inc.
P.O. Box 3066
Monument, Colorado 80132
877-825-5234
www.captionfirst.com

>> KHUE NGUYEN: Welcome to today's webinar titled Integrated Pest Management Strategies for Pollinator Habitat Promotion and Conservation in Agricultural Areas. My name is Khue Nguyen. I'm a chemical review manager in the Office of Pesticide Programs. I am your moderator today. This webinar is produced by the U.S. EPA's Office of Pesticide Programs. The views expressed by our presenter are for educational purposes only and do not represent the official views or positions of the EPA.

In today's webinar we will present the fundamentals of agricultural IPM and cover topics such as cultural management practices, bioeconomics, and integrated insect and weed management. This webinar effort is part of a larger EPA effort to promote pollinator protection and promote the conservation of native habitats.

At this time I would like to introduce our speaker, Dr. Allan Felsot. Dr. Felsot is a Professor of entomology and environmental toxicology at Washington State University. He teaches courses in entomology, IPM, pesticide chemistry and toxicology, and agricultural biotechnology. He is an extension specialist and is involved with pesticide applicator recertification training workshops.

He is also the Entomological Society of America's liaison to EPA's Office of Pesticide Programs. As such, he provides technical expertise to EPA on matters related to insect pest management. Dr. Felsot's research interests include crop protection technologies, best management practices for reducing off-target pesticide movement, and risk assessment. Please welcome Dr. Felsot.

>> DR. ALLAN FELSOT: Hello, everybody. Welcome and thank you for attending. I've conceptualized this presentation into several parts. First, I'm going to make the case throughout that I think IPM strategies will be essential for saving pollinators. And I'm going to make a case that I think habitat issues are really the big problem we're having with pollinators and we're going to go into a little bit of historical aspects.

Then I'll talk about IPM as a decision aid for protecting crop yield and making a profit but one of the objectives of course is of preserving environmental quality or conserving environmental quality. So we'll talk about the four basic elements of IPM that we teach in our classes and on extension circuits and then I'll talk about what I think is very important in terms of what we call the preventive management, the so-called techniques part. There I'm going to emphasize how cultural practices will both promote biocontrol and then also should conserve pollinators. I'll use some data that's published in the literature and there's quite a bit of literature on this that actually gives evidence that this is more likely than not.

Then I'm going to talk about pesticide management because let's face it. In the real world, growers use pesticides all the time and of course we're focused here on the insecticides and so is there management regarding insecticide use that could also be protective of pollinators and really importantly biocontrol agents.

If you look at any headlines over the last oh maybe a decade or so and these headlines are probably reminiscent of going back further than that and that's the idea that bees are being poisoned by pesticides. And of course this started as a concern about honeybees and pollinator honeybees and then of course now the literature is changing and talking a lot about the so called native or wild bees.

So the data seems to have come out quite intensively, what I call hazard identification studies. Because of perception of hazard, this has intensified the concerns.

But it turns out that we can look back in historical record and see that there's always been an issue with pesticides, mainly insecticides and bees. Information from the late 1800s back when arsenicals were just ramping up and then 1920s same thing. Calcium acetoarsenite, or Paris Green, which was very popularly used before World War II in my own state, Washington State. And interestingly enough, one of our professors at that time realized that well if you don't apply these things during bloom then you're not likely to have as many problems.

And of course, in the 40s and 50s we started having chlorinated hydrocarbon insecticides, organophosphates came out in the 1950s and there were documented cases of honeybee kills.

And interestingly carbaryl, which actually has plant growth regulator properties in addition to its insecticide properties is used quite extensively in plum fruit orchards for chemical thinning and this is a quite toxic substance to bees and there are documented cases in the literature of destruction of quite a few counties of honeybees in California, and in the particular year 1967, almost half a million colonies were documented as being affected.

In the 1970s, new formulations came out, what's called the microencapsulated formulations. These are typically plastic-like particles that have active ingredients entrapped in them but their size of about 50 micrometers, or perhaps less, can simulate or emulate pollen grains. And this became a big issue with use of the methyl parathion in its microencapsulated form, Pencap-M, in orchards and then bees taking it back and then of course bee keepers reporting lots of kill in their colonies.

Well if you look in the literature, there's actually some journal literature from Britain where they did extensive studies on honeybee colonies affected by insecticides that were published in 1966 from earlier studies. And then they did a follow-up study in 1994, so we've known about these problems of insecticides in bee colonies for quite a long time.

So it turns out that in science, pollination worries rise as honeybees decline. This has been expressed in what you would call essay type or opinion type writing in science. You'd be interested to know that this article was actually published in 1994.

Now we're talking a lot about neonicotinoid insecticides these days but the date of publication of this article, which is really only a year after a commercial introduction of the first neonicotinoid, imidacloprid, shows that there were always concerns about bees. The concern is not necessarily related to any specific class of insecticides. We know which ones are more potent against bees but we've been dealing with this issue for a very long time.

If we look at some contemporary perspectives and we look at E.O. Wilson, he's talking about wild pollinators. I found this nice little interesting book on the web called *Forgotten Pollinators*. This book was published actually in 1996 and in it they say 62% of some 258 kinds of plants studied in detail suffered limited fruit set or basically they're communicating that “look we're having a problem with pollinators.”

So again, I'm trying to make the point that this problem exists regardless of whether neonicotinoid insecticides are on the market or not. There's something else going on is the case I'm trying to make.

If we look at Dave Goulson from England he's published or been involved (an ecologist), been involved after around 2008 or so with a number of what I call hazard identification studies. Back in 2008, he's talking about declines in bumble bee species over the past 60 years. And then by 2013 he started talking about neonicotinoid insecticides.

Well what's interesting is if you go back and actually read Rachel Carson, she had a statement in the book about clean cultivation and chemical construction of hedgerows and weeds are limiting the last sanctuaries of pollinating insects etc. And I think right there is the issue; clean cultivation, chemical destruction of hedgerows and weeds, or what I would say a real loss of biodiversity, both around crop fields, and with how we are managing our crop fields.

If we look at a study that was conducted in two countries in Europe, what they did is they looked at pre-1980 sampling periods based on records that had been accumulated over the years and post-1980 sampling periods. What I want to point out is although the authors of the paper weren't very fastidious in telling exactly the post-1980 sampling periods what period they ended in, I could tell by reading the data that they were looking at perhaps data available up to maybe the late 90s.

So if you take a look at the trends in bee species richness in the two countries, you can see that many species had been in decline if you compare the pre-1980 to the post-1980 sampling periods up to about the end of the 90s.

And what's interesting is if you look at the array of plant species that were available in the studies, it turns out that there was a change in plant species composition from insect pollinated species, I guess in the vicinity of these areas where they were sampling, to wind and water pollinated, which implies that there was a lot more planting or change in species composition to monocots, which are typically going to be wind and water pollinated. So this change in habitat could be related to the observations of why at least diversity of bee species had been declining.

I want to put things in perspective because there's a lot of talk about how these neonicotinoid insecticides, maybe others, are really destroying our bee populations and limiting diversity so I just wanted you to see I think it's really good to focus on landscape and look at where we actually have crop land in the United States and kind of focus you a little bit more on exactly where the crop land is.

You can see obviously within the northern Corn Belt into the southern areas of the United States this is where probably the most intense use of seed treatments are going on. But if you look over in the valleys of California and up through the Willamette Valley and into the Columbia basin where I live, you can see that of course the cropping systems are much more diverse but there would be an intensity of pesticide usage there. And of course if you go over to the East Coast we'll see it varies there.

So it's really important to focus on just where we're using pesticides most intensively but also that's where you will want to come up with schemes with good cultural management to preserve biocontrol and my argument will be pollinators also.

Again, and I tell all my students this, especially when I'm talking about disease burden, all the viruses carried by insects, and crop destruction by insects, that really if you just tone them out, there's not that many pests in the world but of course they're competing with us. And so I like to say, Mother Nature is meaner than you think.

To illustrate that, here's a nice economic study from Europe. They seem to do a lot more economic studies than in the United States. But if we look at animal pests which are largely going to be insects, although in certain countries rodent damage to stored grain and things would be obviously important, but a lot of this data from these crops that are listed on the left hand side, these were aggregated.

Interestingly, they estimated over those crops about 18% loss in yield under what they considered so called “do nothing” strategy. You are not really purposely managing. And then in the do something strategy, which again is largely insecticide based, you still have a 10% loss. And so it shows us that the insecticides, they're not silver bullets as people said about DDT back in the 1950s. So you try to limit pest damage as much as possible and insecticides certainly help but they have their flaws too.

Why do growers continue to use them if they know they're still going to get some damage and what not? Well if you look at this other economic study from Europe and go down to the bottom of the insecticides column, you can see that the return is pretty good so there's an economic incentive to use these things.

The first area to discuss when you're talking about integrated pest management is to probe the question: well why do organisms become pests in the first place? One of the big issues besides human attitudes and pest attributes is to really compare agricultural systems and so called natural ecosystems.

So we have a limited tolerance for damage of course. Many insects are, in ecology we call them r-strategists, versus k-strategists, so they have very high reproductive potential, although many of the species with this strategy don't live very long. And also we can have these fields, the environment is quite dynamic, and the change in any physical condition or anything that affects what we call the biotic mortality factors, mostly predators, parasitoids, diseases can affect the density of a particular insect that is competing with us.

So the real key though is to prepare natural and agroecosystems because in doing this we get ideas on how we can make our agroecosystems have some of the attributes that we see in natural ecosystems. So in natural ecosystems we see a lot of diversity in species. We see patches. Plants are surrounded by different species or patches of plants and so you have less chance for the pest to kind of march through taking out a so called yield. There's less perturbations.

So the so called biocontrol agents, they are more abundant. I'll be showing you some data on this. If you take a look at agroecosystems, they're completely opposite, especially in Midwestern and Corn Belt agriculture where we have lots of monoculture. We don't grow things with patches around them. Of course in annual crops we're constantly plowing things up and really starting all over.

And this plowing things up and starting all over which dominants so much of our agricultural land areas in the United States is very similar to island ecology where you have an island and then it gets invaded by a particular insect. That insect doesn't have its so called natural enemies that accompany it. It can proliferate especially if it is one of these r-strategists. Think of aphid species asr-strategists. Lots of reproduction. And so these invasives become very successful because their mortality factors, that is, their biotic mortality factors, lag behind before they can become established.

The DDT era was well described in terms of what went wrong by Vernon Stern and colleagues at the University of California Riverside in quite a famous publication in Hilgardia in 1959. And basically, they were talking at that time about resistance to DDT, getting secondary outbreaks of arthropod pests, rapid resurgence of the treated pest species so they had to have repeated treatments. And then of course all the other things that we talk a lot about now, pesticide residues in food, hazards to people and wildlife. And then even in the 1950s there were a lot of lawsuits that were going on especially out of California on pesticide drift.

According to the article by Stern et al., at that time they felt that there was a real limited knowledge of biological science, as we could apply it to let's say agroecosystems, so we didn't think of ecology of agricultural fields at that time. Also because DDT was very successful as a public health insecticide during World War II and shortly thereafter, when it was brought back for use in agroecosystems approximately 1950s, when it really got taken off, it was actually seen as a silver bullet.

And there weren't a whole lot of insecticide chemical diversity at that time and there were few studies on the effects on components in the ecosystems besides just the pests. And of course, we always want to do things now, and at that time, Stern made the case that people didn't think that biotic mortality factors were that much of a consequence for control of pest populations.

So they came up with the idea of integrating biological and chemical control. They didn't eschew chemical control but they focused on biological control and then using chemicals to reduce pest populations that are damaging levels and the most important thing though is they realized at that time there could be selectivity, properties of the chemicals must be compatible with conservation and natural enemies.

So they looked at biological control and chemical control as not being exclusive or alternative methods to one another. They were still hopeful, I guess you might say that they could be complimentary. And the seeming incompatibility of biological chemical control was because of a misperception that an agricultural field is not an ecosystem, but it is, and so really it’s a complex ecological problem to work out.

So they came up with the integrated control concept where they thought it would be possible if you chose the right chemicals to conserve biocontrol organisms, and still be able to reduce the pest pressure to economically acceptable levels. But again, if you read their article they lead with an emphasis on biocontrol and if you're going to use chemicals, then you really have to sort of serve the needs of biocontrol in the system.

Now there's a lot of definitions out there of IPM. There's regulatory definitions. I'm sure your state governments have some kind of definition. Schools have a definition. We academics have a definition. But I want to kind of depose a few of what I think are misconceptions in some of these definitions. Some people say well if you practice IPM you're going to use less pesticide. Well it's likely that you will but that's not the goal of IPM.

Some people will use it as a semantic argument to get more research funding because you're claiming pesticide use will be reduced. Some people say that IPM is integrated pesticide management. I think this argument has been going on among wheat scientists for quite a while. It certainly looks like that from the surface although it doesn't have to be.

And I think one of the most important things I want to emphasize, IPM is not a specific practice. As a matter of fact, IPM as we'll see is a really useful strategy for making decisions, but how did we get to this point? Well it turns out that with DDT use and then the recognition of all the problems that DDT caused, and the main one which really tipped off the California researchers back in the 50s, was the vedalia beetle had been imported near the end of the 1800s to control the cottony cushion scale on citrus.

It worked really well. It was a self-sustaining system and the advent of using DDT basically destroyed that really nice system. That was probably one of the first cases of classical biological control where you import something.

So they came up with this integrated control concept but over time, as we moved into the 60s and 70s it was realized that it's just not about biological control and chemical control, integrating those two things complimentarily, but there are other things you can do and I'm going to be talking about some of these.

So IPM is really a decision support system and here are the objectives. Number one, it has to be an economic objective. If you don't make a profit you're not going to be farming for very long. Secondly, an objective is to minimize selection pressure. So we all are very, very familiar with chemical resistance by the pests. But also selection pressure in terms of we don't want to kill biocontrol organisms. And then of course, maintaining environmental quality.

So one of the most important definitions, or I think most useful definitions, is from Marcus Kogan, retired from Oregon State University. IPM is a decision support system for basically doing the right thing, so you'll make your profit while conserving environmental quality.

The principles of IPM we divide into four parts. Think of bionomics as the biology part. Bioeconomics is the economic part where you're figuring out when you're getting economic injury. You have to have a strong program of monitoring and surveillance, so lots of sampling is needed. And then you're going to deploy compatible and complimentary practices with prevention being the first line of defense.

There's many ways to picture what's going on. This is an interesting model that I've seen. It comes out of I believe the USDA in Arizona and basically a lot of techniques are on this particular slide. These things can be incorporated to any one of the basic steps or principles of IPM that I just showed you.

So bionomics; one of the most important things is you have to identify the pest correctly. So we go out. We put our sticky traps up and we get this mess and you have to have experts actually look at each of these individual organisms and say that's a pest. That's not a pest etc. If you make a mistake though there are consequences.

For example, oh about 15 or more years ago in Washington State, my state, people were catching *heliothis phloxiphaga*. To an untrained eye you can look at the wing patterns of males and females--you see a lot of similarity. Just think if these things were stuck on your trap because some of these moths actually respond to each other's pheromones, not as strongly as their own pheromones, and so if you misidentify this *heliothis* species, which is not a pest of corn, but corn ear worm is, you may make a wrong decision. So really when you're talking about biology, if you don't identify things correctly, it's not going to work out well for you.

So going back to looking at other parts of biology besides identification, we're interested in the whole life history, and once you have identified an organism correctly, its ecology, all this knowledge of ecology opens up to you. We take a life systems approach. So we're looking at abiotic, biotic motility factors, resources available to the population, etc. And we also are going to put a lot of effort into population dynamics. Ultimately, we like to model populations as best as possible.

So if we look at any population over a period of time, as represented by the changes in density, we see that populations go up and down. But for any particular species, there's a general equilibrium position, so think of this as the average over any particular unit of time. And of course, these fluctuations are due to abiotic factors in any particular timeframe, but it turns out that biotic factors such as natural enemies are probably just as important or more so in some cases.

So now that's the kinds of things we look at when we study ecology of the system or the biology in the system. Now we need to bring in economics because that's going to be very important for helping us make a decision, and we have two decision levels. One is the economic injury levels and then the other is a threshold.

So the economic injury level is typically based on actual measurement of populations and how a given population results in a particular unit loss of let's say yield. And the economic decision levels are typically expressed as the number of insects per area, per plant, or animal unit, or some other unit, maybe just a sampling procedure, ten sweeps of a net through a field. You could also look at economic decision levels, express them as degree of plant damage rather than focus on insect or the population itself or maybe a combination of both.

So the economic injury level is the lowest population density that will cause economic damage and that's the key thing. For example, taking a look at this looks like a cruciferous leaf there. We see a couple of holes. That's not necessarily a problem. We look around. We see this interesting larva. It looks like it's chewing on the leaves but if we came up and looked at this cruciferous plant here and we saw that it's really losing photosynthetic efficiency because there are just so many holes, then we would say it's a problem.

So you can have some injury but that injury is not necessarily economic until there's a certain amount of it. So you have to distinguish between damage. So damage is we're really thinking in terms of economics and injury is just what the insect might do to the plant.

It's always nice to appear as quantitative and so this particular formula has been used for a long time to derive a so called economic injury level. This is looking at P, which is the density or intensity of the insect population. I show you this not to impress you that yes IPM has very quantitative aspect but really to make the case that you really need a lot of data. More data about a system is not going to hurt you. The more data you have, the better. You're going to be closer to whatever that economic injury level might be.

And also the economic injury level is not necessarily a static number. It changes. It could change throughout the seasons, year to year and what not. And really because it's a function of cost of management, that cost of course completely uncontrollable by the growers and so that is also going to be a factor because if that's a variable then the EIL is going to be variable too.

So if we now take our principle of population dynamics over time showing you the general equilibrium position, we talk about a damage boundary. So this boundary, crossing that in other words the insect population or pest population might be high enough to cross that. It's where there would be say a yield loss. But that yield loss if it doesn't match in terms of money the cost of control then it's not going to pay you a return if you take action at that point. It's not until the economic injury level is reached that your loss of the yield is going to be greater than the cost of control might be.

Of course you don't want to wait until you get to the economic injury level. You want to kind of be proactive so economic thresholds are action levels if your choice is to do what I call therapeutic control using insecticide. Obviously you're going to probably take action some population density that you've monitored before the economic injury level is reached. It gives you enough time and permits time for control measures to take effect.

For example, if we're using BT, just BT spray, it's going to take a little bit longer than let's say a pyrethroid insecticide to knock out an economically damaging population.

In some cases in the field, if you do good monitoring, you understand the biology of the field fairly well, you may not need any action because you never reached the economic threshold.

Now when you do reach the economic threshold, and obviously you want to use preventative measures from preventing you to getting to that level, then you would go ahead and implement control measures. The point being is that you would not want to wait until the economic injury level. That would be probably too late, so you have to hedge your bets.

In some cases, and here I'm kind of illustrating this where the insect might be frequently at pest status but just a couple of insects, especially those such as green peach aphid, which carry potato leaf roll virus, that virus could spread very rapidly hypothetically from one insect transferring the virus to a plant and then another insect picking it up. So in that case, the economic threshold, the economic injury level, may be very close to each other. This is a really good example where you're really going to want to think a lot about preventative measures.

So that takes care of the biology and economics part. Now you have to, and this is really biology too, you have to look for the pests, right. Obviously the whole purpose, whatever sampling method you use, is to really have a pretty good idea of what that density is and also to look at the dynamics in the change in that density over time. Part of this is also looking at well what stage of the insect are you dealing with? Are you dealing with adults that are going to lay eggs and therefore you're looking ahead? Are you dealing with larvae etc? All those things are very important surveillance.

Now that you've surveilled everything and you've said I've got to do something. It’s going to be preventative or I'm going to wait then use that insecticide, now you're going to be talking about the tactics. So the foundation is the biology, the economics, etc. and now we want to look at what are tactics and potential is.

Our goal in managing pests is we want to reduce the status of the pest. It's not to nuke every insect pest out there. We just want to reduce them to ideally below that damage boundary but definitely below the economic injury level. And remember, we're really trying to preserve other organisms in the system that are helpful. Again, if we distinguish between damage and injury I think we can accept tolerable pest densities better and again I have to emphasize none of this works unless people make money from it. That's just the reality we live in.

So you're either going to do nothing or you could focus on the pest itself and so you use tactics that lower the pest density but it is possible to also focus on the susceptibility of the host plant, for example, and in that case you're actually raising the economic damage boundary. In other words the host can tolerate a lot more feeding before injury becomes economic and thus damage.

The first thing is study, right. Think before you act. How are you going to use the tactics? What is the logical basis? I think I'm making the case that whatever you're doing for a living, farming, orchardist, vineyardist, whatever, you actually have to study. You have to study your field. And then realize that you have choices and tactics. If you always think of what can I do that's preventative first and rely less on going to therapeutic practice which is mostly chemical control, I personally think you have a good chance to make more of a profit later on but it's going to take time and it's going to take really thinking about this.

So integrating techniques will sustain the management program. And the idea here is that if you're just doing the same thing over time, and we know this very well from insecticide use, you're going to get resistance, but even cultural methods without diversifying them can lead to a problem. And we have a really good case with the Western corn root worm and the Corn Belt over two decades ago, discovering that all of a sudden, in isolated areas in Illinois, the adults began to lay many more than expected eggs in soybeans, and so the cultural practice of annual crop rotation between soybean and corn began to break down because they were finding that with the eggs laid in the soybean going to corn the next year, you had much higher populations than you would have predicted.

It's sort of like cultural resistance. It's difficult to understand exactly what's going on. It's a highly, probably takes several gene frequency changes to cause this behavioral shift, but it illustrates that if you do the same thing over and over again, you run the risk, and therefore it is always better to integrate different methods if you can.

What I've listed here is a bunch of techniques where it focuses on lower pest density. So obviously natural enemies--conserving them. Biological control is focused right on reducing insect numbers. On the bottom of this is planting insect resistant cultivars. Insect resistance could be due to several different mechanisms but some mechanisms will directly affect the pest itself.

Alternatively, or integrated with, you can also raise the economic damage boundary. So again you can plant insect resistant cultivars but in this case you're taking advantage of plants that really could grow quickly out of the injury, changing agroeconomic practices etc. So really, you have two different foci here but you can really take a look at both at the same time.

Note that pesticides will achieve this although it's more focused on lowering pest density but if you're interested in durable long-term sustaining good control, pesticides are probably going to be your last resort. We have just way too many issues with resistance have come up and so we really need to diversify our tactics a lot more.

Now let's throw agroecology on top of this. And so, when we say ecologically based pest management, something like that, we're now beginning to look more at let's call it habitat management, diversity of planting within a field, around a field, etc. So it's still all about integrated pest management in terms of the principles I've given but now you really cannot ignore what you're actually doing and I would like to say from an agronomic standpoint: Prevention, first line of defense. And again, to reiterate, you're either focusing on the pest and so basically focusing on the pest, you're lowering the general equilibrium position. If you're focusing on the plant then you're raising the threshold of economic damage.

When I talk about prevention now I want to focus specifically on cultural and biological control and really the relationship between these. They almost can't be separated. One begets the other, so to speak. So the cultural management itself is very effective for raising the economic damage boundary especially if we look at agronomic factors that we need to employ to make the crop very healthy.

So cultural management as an example, it might be avoiding monocultures and making sure there's more diversity around the fields, within the field even, strip cropping as shown here. Proper fertilization, irrigation etc. This also enhances biological control. Biological control of course is really warranted towards lowering the pest density directly.

And if we do cultural management properly, then we will enhance the biological control organisms. This is called conservation biological control as opposed to traditional biological control, or classical, where you're importing something in. I would say that that's a difficult process, however we have at our hands the real ability to conserve the biological control organisms through our cultural management.

At the same time, I would argue that if you're preserving or conserving the biocontrol organisms through good cultural management, you're also going to be contributing to pollinator conservation and I would hold that the literature would suggest that you're going to be using less insecticides and especially true if you have native habitat or semi-native habitat around the fields and I think we have to move from an individual field here now and look at more of a landscape level. What's everybody doing in a particular region?

So conservation biological control then is really thinking about how we can change management of our systems such that the biocontrol organisms are preserved and at the same time I would argue that if you can do that then you're also going to be preserving the pollinators.

Okay so what I’m going to do now in the next set of slides is I went into the literature and of course when you're studying the literature you can bias by things that you think is cool, but I just kind of want to illustrate what we see in the literature, and it was very easy to download tens and tens and tens of articles. I think what I saw was a lot of bias towards research coming out of Europe but I think it is very instructive to illustrate some of these points, and also provide evidence that this can work in terms of sort of the relationship between good cultural management and conservation of biological control and then conservation of pollinators.

In this particular study in Australia, they looked at arthropod assemblages on six particular crops. They looked at two different landscapes in Australia. It was only a one year study but what they noticed is that in those landscapes that had lots of native plants that had higher predator densities, in other words the native plants in the areas had higher predator densities than the crops, and the crops had higher pest density.

So here we looked at just pest density and we could see in the brown here the crop throughout the year except for October tended to have greater pests. But if you look at the predators on crops they were lower and much higher on the native vegetation so planting or preserving native vegetation as much as possible around crop areas this suggests that there was going to be a lot more predators and of course they could be mobile and move into the fields.

In this particular study out of Switzerland I believe, they were looked at wildflower field strips. Now in this particular case it's not very clear from the article but it seems like the wildflower field strips were basically adjacent to the fields or maybe around the field. And so they were looking at the cereal leaf beetle, Oulema.

And what they found is if they looked at just counting the number of eggs, which pretends what the population density might be, if there were no flower strips as they called them around the fields, they tended to see a lot of eggs especially near the border. Here they got five meters.

Now as they moved into the field ten meters, this effect seemed to go down. Again, same thing, near the so called flower strips a lot less larvae, shown here in the green, and if they looked at the adults they found about the same thing. There really wasn't much difference if you moved into the field.

Now that's nice but it does raise the idea. It's like, well what if you move the flower strips not just from around the border, is there any way to begin to plant these more in the field without reducing your overall yield?

In this particular case, they were looking at adjacent vegetation and the hypothesis was: will it enhance the natural enemy population? So this is a study focused on vineyards, over 60 vineyards, and they were looking at those that had no vegetation or vegetation on one of the margins. They were looking at bare areas or no vegetation might be two vineyards adjacent to each other. They were looking at what they call shelterbelt vegetation. In the article they list particular common names of species that were in the shelterbelt and remnant is sort of like semi-natural habitat, so it's whatever they actually grew there.

And they looked at a lot of different natural enemies, both beetle predators as well as hymenopterous parasitoids, and they found that when there was no vegetation adjacent, these natural enemies were quite low. They got the best densities and natural enemies with the shelterbelt vegetation, and then the remnant vegetation--they weren't really statistically significant. Now of course it's going to be different, for different, in this case families, of different insects but the point is it's possible to enhance their populations.

In this particular case studying the light brown apple moth, egg predation was greatest when the vineyards were adjacent to native vegetation, so again this looked at a specific insect pest in these studies and so there's no doubt about it:If you have field next to field next to field, then you don't have this diversity of other vegetation whether it’s purposely planted or at least remnant of the native, you're going to have a lot less biocontrol agents in the system.

In this particular case, this was a sort of a meta-study of 24 different studies that they found in the literature and here they were expanding out from what's going on around the field to more of a landscape level, so more of not necessarily a broad regional level, but just a much larger level. And so they actually characterized how much cultivated land was in a particular landscape, and how much semi-natural.

What they found is that in the semi-natural areas, the pest populations were lower. In other words, when a landscape was dominated by semi-natural areas, pest populations were lower. And more frequently they found cases where pest populations were lower than they did find of cases where pest populations were up. So it's not perfect. In other words, there could be some cases where your pest population might be influenced to a higher level by semi-natural vegetation. We can't discount that but more likely than not you're going to find cases where the pest populations are down.

Now when they turned to instead of looking at pest abundance to so called biocontrol organisms, a number of cases--again they found that biocontrol organisms were much higher in those landscapes that were dominated by semi-natural vegetation as opposed to the cultivated areas.

In this particular case, they did more of what I would call a reductionist study although what's nice about it is they worked in different soybean fields, commercial fields. And what they did is they used exclusion cages to keep out predators that would be feeding on aphids such as the invasive soybean aphid. And they found that if they put exclusion cages in plots within these fields, then they had a heck of a lot more aphids. And they also look at biocontrol services index relative to diversity of vegetation in the landscape, and they found that their index went up. In other words the more biocontrol services, as they like to describe it, the more diverse the landscape was around the fields they were studying.

There's a lot of talk about comparing organic farms to conventional farms and people saying organic is better than conventional. First of all, let me say that one of the problems with these definitions when you set them up as variables is that organic farms at least in the United States are part of a marketing regulation, the National Organic Program, and conventional farms really don’t have any scientific status but we tend to be people that probably use insecticides, mineralized fertilizers, and things like that.

But what's really interesting is in this particular study where instead of focusing on biocontrol agents, they're focusing on diversity of butterfly species, and I wanted to bring this in because there's a lot of concern about the fate of the monarch butterfly lately. What they found is that it is the habitat, not necessarily the agronomic practice, which seems to have a big influence on the diversity of the butterflies you're going to find. So if they look at the number of butterfly species on organic versus called conventional farms as they defined them, it was when the landscapes in the places they surveyed.

And what they did is they used matched pairs of organic and conventional farms so these had to be fairly close to each other. They couldn't be influenced by lots of natural areas outside, so they could have a better comparison. Diversity had not related to the agronomic practice per se. It was related to how heterogenous the landscapes were. Homogenous landscapes--organic was better than conventional but still homogenous landscapes are the problem.

And they looked at abundance of butterflies as opposed to diversity of species. They found exactly the same thing. Homogeneity of your landscapes is not conducive to conserving organisms we want to conserve. And when they looked at the landscape heterogeneity, regardless of whether they were dealing with organic or conventional farms, butterfly density went up.

We've talked a lot about milkweed. This particular study was actually published by a colleague in my department, the Department of Entomology at Washington State, and I thought this was nice because David James was focusing on milkweed, and I thought this is great because we're talking a lot about the loss of milkweed. Some people prescribe it as due to use of Round-up, so I said let's focus on milkweed.

Of course in the Midwest you're talking about a particular migratory population of monarchs that's different than the migratory population of monarchs out in the Pacific Northwest where I live. Here our monarch populations make it down into California where of course the Midwestern monarchs make it all the way down to overwinter in the highlands of Mexico.

But what was really interesting is there's not been a lot of study on just what kind of insects you find on milkweed. What they found is that there's quite a number, when they set up traps around milkweed just growing out in our natural environments here, lots of wasps and bees were found on them, so called things they described as bugs were pretty low.

What's interesting is they found that native bees really like the native milkweed, so if we're concerned about wild pollinators we've got to think about what kinds of plants are really attractive to them, and here we're saying milkweed is really nice. Maybe we need to look at milkweed less as a weed and preserve it outside the field especially in the Corn Belt. Maybe there's some value to that.

Now we've gone through so called preventative techniques. I hope I made the case that if you do good cultural management not only do you conserve biocontrol agents but I think I made a strong case that you're going to have a lot less pest pressure etc. Okay, so what if that doesn't work, or what if you feel that you really need to have those insecticides available at hand if the system sort of gets out of hand and you need to apply that therapy?

Let's take a look at well can we manage this sort of calling-- the tradition of the integrated control concept. Can we choose selective pesticides? I'd say today we have a much better opportunity to choose selective insecticides than occurred in the 1950s. Of course, there's a lot more microbial pesticide products. Some of them are more fast acting than others of course. I'm not even going to get into genetically engineering these toxins in. I think that's a whole other webinar but there are other things you can do that I would call therapeutic.

Early harvest; there's studies, a lot of older studies on that. And then some people for soft bodied insects, like in melons or maybe even cotton, are using mechanical removal using vacuums, so it's not just about insecticides but let's face it, that's the most predominant therapeutic technique so we have to look at selectivity.

Is it possible for them to be compatible? This is an interesting article published in 2012. I really like this because they really try to look at the selectivity of the different major classes of insecticides, chemical class of insecticides, or you might even say mode of action class of insecticides. And on these graphs, what they did is they show in a bar graph the LC_{95} and then they also showed the field rate sort of placed in the same unit so they can be compared. And in the case of organophosphates, and many of the carbamates, probably all of them too, we could see that the field rates are much higher than what would kill the statistically call the lethal concentration to 95% of the tested organisms. So obviously these are not selective. These are the things that if you have a choice, you want to avoid these.

I'm going to start with the avermectins and phenylpyrazoles like fipronil first. We have a little bit of more of a mixed picture. There's a little bit of difference between a couple of the chemicals, although avermectin is not used. It's used more of a vet compound. But we see that again we run into the same problem where a number of them, the field application rates are higher than the statistical estimate called the LC_{95} where you kill 95% of the population so again, this is not going to necessarily help.

On the other hand, if we look at the neonicotinoids, these are probably as best as possible fitting the so called reduced risk mode, but the point thing is, their field recommended rates, at least in the organisms that they were testing in this particular study, and they were testing the parasitoid trichogramma in the Hymenoptera family, these field rates are lower than actually what would kill that.

Now is this true universally? No. I can show you articles where something like imidacloprid tested against some lady beetle species and it turns out it can be toxic. Also timing of these can be very, very important too. But in general, just looking at the statistical estimates for LC_{95} field application rates, in general we can say that neonicotinoids are that selective brand or chemical class we've been looking for.

And then there's some other ones that fall into that same selectivity such as insect growth regulators, whether they're juvenile hormone analogs, chitin synthesis inhibitors, and this particular study shows that the pyrethroids -- you've got to be careful. Some of them application rates are right at that LC95 so that's not good. One of them, fenpropathrin, is a much older one. That's okay.

But I do want to say something about pyrethroids regardless of this data. You're going to get mite problems if you use pyrethroids like in an orchard or something. It just really knocks out their predatory mites and then you get outbreaks of phytophagous mites.

There are some very selective, more modern, although they're not so young anymore, acaricides that are available so if you're going to do that, pyrethroids are cheaper, but think about how you might push the system over the edge so to speak and cause a problem you don't intend to. But the point of this is there is selectivity if we think about this and do enough study on these things.

This was an early attempt way back from 1990. I took this table from this paper and I modified it by throwing in imidacloprid and acetamiprid. Now imidacloprid of course is one of the most toxic insecticides to bees along with clothianidin and thiamethoxam. You can see that here. Here's the application rates so if you applied the application rate in this simple hazard index that I created you can see there's no doubt about it, imidacloprid is the most hazardous and chlorpyrifos, malathion, the organophosphates, are not far behind.

Now we don't want to throw the baby out with the bathwater so acetamiprid is also a neonicotinoid. It's heavily used in orchards today. It has supplanted the use of malathion and organophosphate. This is pretty innocuous on bees so again there is selectivity even within the neonicotinoid class which is generally thought of as being incredibly toxic to bees but specific chemical structure does make a difference so even in that class there is selectivity. These are the herbicides down there just to show you that we don't really think herbicides are much of a problem.

When we're talking about can we manage and choose insecticides? I think it's very important for people to go back and actually read the product labels, which some of them run 10, 15 pages long of data. So I'm going to take two here and I want to show you what's on these labels that I think adds protective management in the system that we tend to forget about.

One of the things to remember about every product label that product labels have the force of federal law. I always like this first sentence that says -- every label that is on the extension circuit I point out. It's a violation of Federal law to use this product in a manner inconsistent with its labeling.

And what we're seeing now is this panel on more and more the modern labels that warn the user that there's going to be application restrictions and that of course implies that the product can be very hazard to bees if not used in the way the label prescribes.

So those bee labels are important. So the bee labels are sort of a warning but let's look at what it says. In this particular case for imidacloprid formulation, do not apply pre-bloom or during bloom or when bees are foraging. The idea is we need to move from hazard to risk. Risk incorporates the idea of exposure. Hazard is just hey it doesn't matter how much is there, what went wrong? How are you negatively affecting bee’s behavior, colony strength, and all that kind of stuff?

But if you reduce the exposure, then regardless of the hazard you're mitigating that hazard to very low levels. In other words, you're reducing the risk. I think this is really important to look at how we use these things and how exposure might happen or how it might be avoided.

So I wanted to show you on thiamethoxam Actara label and this one is very interesting. It says on the bottom here if bees are foraging in the ground cover and it contains any blooming plants or weeds, always remove flowers before making an application and then they tell you how you can do that. Now is that practical for an orchardist?

And this is actually very applicable to orchards because I live right next to orchards and there's always a ground cover in the middle, right. They typically mow these so they're going to be doing that anyway, taking away any blooming flowers but you can see that the label is really thinking about how could exposure happen that's not just related to applying something to the crop but the habitat around there too. We have to think about that.

In conclusion I want to emphasize IPM is a systematic strategy for making decisions. That's what it is and then of course all the principles I talked about are the things that you do, starting with biology and of course pest identification is probably one of the most important things you can do.

We have to rely on our strategy and decision making by focusing on agricultural systems from an ecological perspective. Anything we can do to make them more like natural systems. And then of course economics is important. You have to make a profit.

Now IPM is not going to favor more or less pesticide use but if you use good tactics like cultural practices, enhanced plant and animal diversity both within the field and the landscape level, you're going to have lower pest density, higher tolerance for pest injury, and if this occurs, it's more likely than not that you will use less pesticide. Remember pesticides are not perfect.

I showed you a slide earlier on that you still estimated and it was kind of estimated you could still get maybe about 10% loss over a bunch of different crops. And it turns out that these biocontrol organisms which are often especially the parasitoids are fairly sufficient at finding their host pest will help the pesticide.

If you are going to use pesticides and again I'm talking about insecticides, then you have choices in today's chemistry, and so it's always good to think about using the least hazardous material possible.

And then I always end every talk I give an extension about it's always very important to follow label directions because it is the Federal law. So with that I've concluded my presentation and I think now we have time for some questions.

>> KHUE NGUYEN: The first question. Can you give any examples of crops where biological control by itself provides effective management of key principle pest of the crop?

>> DR. ALLAN FELSOT: Well the one that I talked about historically has been the importation of the Vedalia beetle for control kind of cottony cushion scale. Of course I can't historically say that was because everybody really understood the biology well. Part of it was luck but the key thing there on importing things is they have to get established.

If you read a lot of the literature, I think there's a realization that you have to avoid relying on just one thing. Think of conserving biocontrol organisms as being a key factor to suppress the population. You're also doing cultural methods that can help also, right. So if you're going to do some strip planting, companion planting, if you were to plant say a crop in the plant family Fabaceae what we call leguminous plants with one that was not a nitrogen fixer, over a long run that's going to be very helpful. You're going to potentially, if you do nitrogen counting, you'll be using less of that. You'll also still have all the nitrogen that the plant needs and so it would outgrow.

I would have to do a deep dive in the literature to actually pull out studies where they say yes, this is definitely economic control but again you're dealing with biotic factors that are themselves very variable so maybe one year it might but another year it doesn't. So I think the key thing here though is go back to the word integrated is to use lots of different techniques and do everything you can to preserve the biological control organisms but just don't stop there, right. You have to keep on measuring. You have to look at your field over many years and see what's going on.

>> KHUE NGUYEN: Okay next question. Is creating landscape diversity within an agricultural ecosystem an economically viable option for the farmer?

>> DR. ALLAN FELSOT: Oh for sure. So I was at the University of Illinois for almost 15 years before I moved to Washington State back in 1993 and I did a lot of field sampling. I was mainly doing a lot of environmental chemistry in ag fields at that time and it was just amazing to me how people would mow everything right up to the field edge and then of course you have tremendous highway system and everything gets mowed there especially in the median strips.

You know it'd be nice if you could figure out a way to economically do more strip cropping within the field. But a good place to start is just do something around the outside. Why do we have to have it clean mowed all the time? I never understood that. If you can, let the native vegetation grow. If you have enough moisture you can plant certain things. Out where I live it's really dry so you can't waste your irrigation water around the outside of your irrigation circles and things like that.

So I think it's worth trying slowly to see how your yield might go. I'd also think about this. If you could rely less on purchased inputs by creating more diversity then of course that could potentially up your profit right because it's how much money you spend, not just what your yield is.

>> KHUE NGUYEN: Okay next question. Given the increase reliance on monocultures, do you see an opportunity for cultural shifts to IPM?

>> DR. ALLAN FELSOT: Well I think growers have been using IPM, various elements of IPM as it is. So for example many, many years ago decades and decades ago, second generation corn borer or is it first generation corn borer resistant corn was bred, so that's host plant resistance so you could argue that’s a preventative method.

When the questioner says increasing monocultures, the Corn Belt has after World War II kind of gone towards monoculture. Let's think about it in terms of time also. For example, about a decade ago, I saw a talk where instead of just doing a bean corn rotation, the presenter was talking about well we might need three year rotations, so it's not just what you're doing within a year. It's thinking ahead several years, and so if you brought in another cereal crop or I guess even a year of alfalfa or something like that or maybe fescue hay, if you have enough land and what not, you can think in terms of diversifying over time in addition to diversifying within a field or a landscape.

I think the problem is we want to make all these changes right now but I think, in the Midwest anyways, cropping diversity and looking over time I think there's some publications that show this could work but it's really more cross seasons than what you're doing necessarily within a season.

>> KHUE NGUYEN: Okay next question. Can you describe the difference between IPM, integrated pest management, and BPMs or best management practices?

>> DR. ALLAN FELSOT: So best management practices would be -- I would put it, it's what you do within the context of an IPM strategy, strategy as a decision making tool with the objectives I mentioned before. So I'm not sure. I think we're kind of maybe conflating tools you would use, best management practices, within a holistic system of how you deploy those tools. So I think it's important to get the so called definitions right.

>> KHUE NGUYEN: Okay next question. You mentioned that herbicides aren't really a problem. Can you talk about weed management and its indirect effects on pollinators? Do you think it is possible to manage weeds in a way that allows both flowering plant diversity and acceptable yields?

>> DR. ALLAN FELSOT: Okay so within the field for a very long time, this is not something new with the advent of Roundup ready crops. I mean rows were very clean. When I started walking fields in the Midwest in the 70s, I guess I did my first field sampling in the mid-1970s things were very clean. And there was always a case where if you had escapes and of course at that time they were using a lot of pre-emergent herbicides which of course they still do. Atrazine is probably the number one pre-emergent herbicide used in corn production today still.

They did a fairly good job but if you got escapes you would hire maybe high school students to walk in, rogue out the escapes, so all the way back then fields were very, very clean. So I don't think that perspective is likely to change any time soon but I want to go back to what's outside the field. I think that would be very helpful. Now here's the thing. You've got to know what your species are, right, so you don't want weeds that you might have in your field to get established outside the field because they're going to be growing out the seed bank.

You could look at cover crops. Cover crops are studies out there. I bring a couple of them into the IPM course I teach and cover crops can be very suppressive. Again, a lot of the research is done in academic institutions but it's a little bit easier for us out here in the Northwest where we have a lot of commodity commissions funding research but if you could maybe do experiments on your own field. Set aside a part. Try some cover crops. See how it is. Do some measurements.

I know it's using a lot more resources but often the answer to these questions happen really within an individual field in the context of that field and its surroundings. So it becomes very difficult to say well this is a good solution for everybody. But the literature that is available does indicate that there are some solutions especially in the cover cropping area.

>> KHUE NGUYEN: Next question. Where does seed treatment fit into integrated pest management, especially in terms of the "think before you act concept"?

>> DR. ALLAN FELSOT: Right, so for a long time I've always thought of seed treatments as being prophylactic treatments but seed treatments didn't start with the advent of the neonicotinoid insecticide commercialization. Seed treatments have always been used. When I was younger, all corn seeds were treated with not only captan fungicide, they were also treated with lindain. Until lindane registration was basically canceled I think around 2005, lindane was used a lot on weed seeds although imidacloprid was coming in. So they've always been used as a prophylactic.

In some cases, they may work but again because there's a lack of intense monitoring, we don't really know what we're going after. Now, in some cases if you grow corn with say after a grass field you might have some wire worm problems. You may get seed corn maggot or something like that. Seed treatments could be very helpful, but if you don't know, you may be wasting your money. So I think they could be helpful if you know that you're going to have a particular pest, and there's some literature that indicates if you follow say corn after like say a grass field or a particular kind of field, you might, but I look at them as being prophylactic. But then again, it's very hard to get too generic with these answers.

So let's say you're growing melons or something like that and you're in an area where you're always going to know you're going to have let's say striped cucumber beetle which transmits bacterial wilt, especially in the Midwest or something like that. Seed treatment could be very useful because you know what you're trying to control there, right. But I think a lot of times we're just throwing them out there without really thinking really what is it doing?

>> KHUE NGUYEN: Okay next question. What is the impact of urbanization on your call for increased biodiversity in the agricultural ecosystem?

>> DR. ALLAN FELSOT: So in one of my earlier lectures in my IPM course I go through this thing. There's a website called "Farming On The Edge" and it shows how good productive farmland is being eaten up by housing development and more what we call exurbs. Everything is moving out.

And yes, it does reduce biodiversity. It's one of these social things. You almost can't stop it but maybe it's time that people who plan out these suburbs and exurbs think about how they can diversify within. Lately there's been an article or two about looking at bee diversity within urban scapes and showing there was a surprising amount of diversity and it could be due to that in some cases, these areas where they studied, they actually had a fairly good diversity of flowering plants or what not.

So while personally because I've seen it myself because I live right next to farm land and I've seen lots and lots of houses come in, it's disturbing, although it's private property. I can't do anything about it. I think we can think about our urban development in a way that also is compatible with say farm land that it is adjacent to.

>> KHUE NGUYEN: Next question. Are there any alternate bee species other than honey bees that might help with pollination of crops?

>> DR. ALLAN FELSOT: Yes, as a matter of fact there's an article or two just really published fairly recently or maybe I saw it recently, oh there's a really nice study on blueberries. Isaac Rufus, they looked at the blue orchard bee. As a matter of fact the New York Times just had an article about this the other day, so there are these other pollinators. I think I read an article a number of years ago, not too many, where they were comparing honey bees with wild pollinators for melons. Oh the pollination intensity rate was much better with the wild pollinators.

Now of course, there's certain what we would call wild pollinators, bumblebees there are some. I think there's at least one or two bumblebee species that are managed like honey bees are managed. Of course somewhat of a different biology so there is that aspect and if one wants to get into using bumblebee colonies that might be very helpful.

But the key thing is beyond that especially when you're dealing with solitary bees and don't forget there's certain flies in the order *Diptera* such as flower flies, family *Syrphidae*. These are important pollinators too. I mean lots of different insects can pollenate so the key thing is to think beyond just bees but think about the cultural practices and habitats preservation or conservation that will allow all of the species that could be out there to thrive.

>> KHUE NGUYEN: So we only have two more minutes for questions. It sounds like you were talking about tools that require long cycled land use management practices. How do you apply those to annual cropping decisions in light of very cyclical crop prices?

>> DR. ALLAN FELSOT: That's very difficult in the Midwest Corn Belt. I would say the Corn Belt without necessarily insulting anybody, its quite individualistic. Let me give an example of how you can work together as a larger community and it's only an example. I can't say it's applicable to say Corn Belt type agriculture.

So for example on the western side of my state, Washington, what we call the wet side, there's a lot of cruciferous, Brassica seed crop, right. They're growing seeds that are then marketed across. A lot of these growers, they organize themselves in a group and they keep track of who's planting what where. They have isolation distances.

So the thing that I see as a possibility is people getting together and saying, hey this is what I'm going to plant this year. Somebody says well I'm going to plant this this year. Think more strategically as a community of planters and not just somebody, who hey I've got to make a buck and I don't give a damn what's around me.

The value of that is and this is my hypothesis is that if you could work together as a community to sort of plan out your landscapes you have a lot of potential by encouraging more diversity in thinking about the different crops you're growing adjacent to each other and of course the Corn Belt you don't have a whole lot of crops that you might be thinking about that you could plant.

But it may be possible to overall lower your costs with enough time. And if you lower your costs then you're going to increase your profit even if you're taking a little bit nip off that so called 200 bushel per acre yield because your costs are down and really that's what profit is based on the costs and the return.

So it really does take community effort but it's really a social problem I think but it can be done because I've seen it out here where people do cooperate on a more landscape level with what they're planting, where they're planting and things like that.

>> KHUE NGUYEN: That's all the time we have for questions. Thanks for joining us. Have a good day.