Go ahead...

Good afternoon everyone and welcome to our webinar my name is Nancy McNitch and I will be your moderator today. Our speaker is James McDonald, James is the Chief of the Structure and Technology and Productivity Branch at the Economic Research Service US Department of Agriculture. Among other areas of research his branch analyzes the application of new and existing production practices, management systems and technologies on farms. His branch is also responsible for the annual Agricultural Research Management Survey or ARMS which is USDA's primary source of data on farm and farm household finances and field level production practices. I think we're ready to start so James you can begin the presentation now.

Alright, thank you Nancy and good afternoon to everybody. This research is based on an ERS report released in late April of this year. The lead authors of that report were Michael Livingston and George Hernandez-Cornejo, I supervised the research for the report as well as the production of the report. Let me start with a little bit of background on glyphosate, it's commonly known by the trade name Roundup although there are many generic versions of glyphosate around as well. It is a popular broad spectrum herbicide, there are several reasons why it's become so popular. First it's quite effective at controlling many different types of weeds, secondly it breaks down quickly is soils, more quickly than other herbicides, that provides some environmental benefits and also provides flexibility in weed management for farmers, third some crop varieties, the most well known would be varieties of soybeans, corn and cotton but it also includes more recently alfalfa and sugar beets have been genetically engineered to be tolerant of glyphosate allowing for what's called post emerging spraying, that is you can spray the herbicide after the crop emerges from the ground and kill the weeds but not the crop. This combined practice of herbicide tolerance and use of glyphosate also allows for less tillage as a weed management practice. Less tillage saves farmers money directly it will also reduce the soil erosion and can improve soil and water quality. Finally since glyphosate went off patent in 2000 its price has fallen making it relatively inexpensive as well as effective. Now I've just tied the spread of herbicide tolerant seeds to growth of glyphosate use and I want to focus in on that a little more on this chart, it's a bit complicated so let’s take some time with it. On the left axis of the chart we're charting the spread of herbicide tolerant seeds in corn and in soybeans measured as the proportion of planted acres planted to herbicide tolerant seeds. The right side axis is going to measure changes in the quantity of

glyphosate use as well as the quantity of all other herbicides so lets start with seeds. Notice we start in 1996 the first year of commercial introduction of herbicide tolerant seeds, the red line represents soybeans, the percent of soybean acres that were planted with herbicide tolerant seeds. You can see that that increased very rapidly after initial commercial introduction in 1996, by 2007 more than 90 percent of soybean acres were planted with herbicide tolerant seeds and the proportion has plateaued in the low 90 percent since then, it's continued in that range, the blue line represents corn planted acres with herbicide tolerant seeds, you can see that took off much more slowly and in fact in 2002 still at just about 10 percent of corn acres but then began to rise rapidly after that time and by 2013 about 85 percent of corn acres were being treated, planted with herbicide tolerant seeds. As those seeds grew you can see that use of glyphosate also grew rapidly, glyphosate is the green dashed line read off the right hand axis, in 1996 we were using about 10 million pounds of glyphosate annually, by 2013 it's about 200 million pounds and you can see it growing steadily throughout that period so that introduction of herbicide tolerant seeds led to a sharp increase in the use of glyphosate. The dotted line is the volume of all other herbicides used in corn and soybean production you can see that declining through time essentially glyphosate replaced other herbicides, you see it declining until about 2006 when it stabilizes. You can visualize adding those two lines together, glyphosate and all other herbicides and realize the total herbicide use between 1996 and 2006 changed very little. After that time you can see that the use of all other herbicides has stabilized and even grown slightly in 2012, 2013 while glyphosate use continued to rise so the total herbicide use applied to corn and soybeans increased after 2008 although I should note that some important part of that increase is expanded acreage of corn and soybeans, corn and soybean acreage in total increased by about 15 percent after 2006, the application rate of herbicides per acre remain constant in corn but has increased in recent years for soybeans. Okay, let’s talk a little bit about resistance, because of its benefits glyphosate use as you can see in that previous chart became very widely used in US Agriculture. Widespread use has lead to weed resistance to herbicide that is some weeds survive spraying, that, that they're an innate trait for being resistant to glyphosate, those weeds can propagate, lead to more weeds over time and we get a growing problem of glyphosate resistance. As long as we're looking at this picture lets also visualize a little bit an issue that’s going to come up later in the presentation that is the dispersal of weed seeds. We can see this picture a nice clear field, the crops coming up, it's been sprayed, you mostly see dirt except for that very large weed right in front, that's a weed that is resistant to glyphosate. Now the seeds from that weed may be dispersed by the wind into neighboring fields, maybe picked up by birds or animals and dispersed into neighboring fields where we'll then have a glyphosate resistance problem in

those other fields. I want you to keep that in mind because we're also going to talk about some spacial dimensions of this later in the presentation. Alright, this particular research project had three major goals. First we want to estimate the extent of weed resistance to glyphosate and the impact of that resistance on farmers cost and returns. Secondly we want to identify the major drivers of growth in weed resistance to glyphosate and third we want try to evaluate the economic impacts of some different strategies to trying to manage resistance and I'm going to consider those each in turn as we go though the presentation. A key resource in doing this is USDA's Agriculture and Resource Management Survey that is a large annual survey of US farms that is the primary source of financial information on US agriculture for USDA. An important component of that survey is what's known as ARMS Phase II, that is in each year under Phase II we approach up to two, we select up to two target crops and we form a sample of producers of that target crop, we approach the farmers and if they agree to participate we select a field at random and we ask them a long, long list of questions of everything that goes on in that field. I should add, I should add we had enthusiastic response from farmers to this survey our response rates range from 70 to 80 percent quite high for a voluntary survey that is fairly long and involved. Now I had mentioned that we go up to two commodities a year that means we repeat a commodity every few years so for corn we'd run ARM surveys in 2000, 2005 and 2010 and we will be back to ask farmers about the 2016 growing year, for soybeans we had surveys in 2002, 2006, 2012 and we'll come back in 2018, we also cover several major field crops such as wheat, cotton, rice, peanuts, barley and oats and I should add in following the path of glyphosate resistance we added questions for corn in the 2010 survey and for soybeans in the 2012 so our empirical analysis comes, much of it comes from what we learned in those surveys. I should add that we focus on corn and soybeans because they're the two largest field crops and they are major users of glyphosate. Now we've also taken that ARMS data and we've used it in some models of farmer decisions, we've combined a biological model of weed growth and glyphosate resistance with an economic model of costs and returns to weed management in what we call a Bio-Economic Model. In that model which we apply later in this presentation we've used data from ARMS, some other survey data from USDA's National Agriculture Statistic Service and studies conducted by university plant scientists in support of the Bio-Economic model. Now, to begin with what have we learned out of ARMS? First growers report that glyphosate resistance is much more prevalent in soybeans than in corn, in 2010 in that corn survey corn growers reported the presence of glyphosate resistance weeds on 5.6 percent of their acres two years later when we surveyed soybean growers soybean growers reported declines in glyphosates effectiveness on 40 percent of their acres. Now we were learning more about how to ask these questions and so they're asked

in slightly different ways in 2010 and 2012, we think we got better in 2012 in addition of course resistance was probably growing between 2010 and 2012 nonetheless we feel quite certain based on the information in the survey as well as other survey information that there's a substantial difference in the extent of glyphosate resistance in soybeans as compared to corn, I'd like you to keep that in mind as we use it to explore what the main drivers may have been of growing resistance. To look at that let's start with a little bit more information on what we knew about the use of glyphosate and of other herbicides in corn and in soybean production based on the ARMS and some earlier surveys that we had run through the 1990's. This chart shows separately for corn and for soybeans quantities of use of glyphosate which is the blue bar and all other herbicides which is the red bar and we're reporting it in millions of pounds of active ingredient. Notice for corn until about 2000 it's almost all red, it's a little bit of glyphosate growing there at the bottom in 1999, 2000 and you can see the blue bar grow a bit and continue growing and grow really fairly rapidly from 2005 until 2010, nonetheless most herbicides used on corn were not glyphosate they're other herbicides and typically glyphosate would be used in combination with other herbicides in corn. If you compare it to the soybean chart you see quite a different pattern, we're starting in 1996 with a moderate amount of glyphosate, use expanded quite rapidly so that by 2006 glyphosate accounted for a very high proportion of all herbicide use in soybeans. You can see in 2012 as resistance started to grow farmers shifted to some other herbicides but glyphosate is still by far the dominant herbicide used in soybeans. Here's a related look, this takes a look at how herbicides were combined or not combined on corn and soybean acres. Here we're now, we're looking at different types of herbicide application strategies, four different types and we're looking at millions of acres to which they were applied. The four different alternatives here are first the blue, the lowest bar where a farmer reports applying only glyphosate to his acres. The red bar is glyphosate and other herbicides are being applied, the green bar is no glyphosate only other herbicides and the very thin purple bar at the top of these bars is no herbicides used at all. You notice for corn that there is a growing fraction of acres for which farmers are using only glyphosate but it's still a small fraction of acres. Typically farmers by 2010 were applying a lot of glyphosate but they were applying other herbicides as well, they were mixing different modes of action of herb, of weed control on their farms. Compare that to soybeans again, notice the rapid growth of that blue bar so that by 2002 and certainly by 2006 most soybean acres are being treated with glyphosate only and of those that were not being treated with glyphosate only they were being treated with glyphosate plus another herbicide. So glyphosate was covering a higher share of soybean acres that was being used more exclusively on soybean acres. Finally one last bit of information that we glean right from, directly from

our ARMS survey data is to look at the cost and return affects of declines in glyphosate effectiveness we called, we asked soybean farmers in 2012 whether they had observed a decline in the effectiveness of glyphosate on their acres. Right now in this breakdown we're looking, we're comparing those that said yes there is a decline to those that said no I haven't observed any decline. In the report you'll see this is a somewhat more complicated analysis than a simple response I'm giving you here but this is enough to give you the flavor of what we were doing and we can see that this has several different types of impacts. First those that hadn't observed a decline in glyphosate effectiveness had slightly lower yields. In that year corn was selling, soybeans were selling for 12 to 14 dollars a bushel, so a slight decline of one bushel an acre does have some noticeable revenue impacts. Those who had observed a decline in glyphosate effectiveness also had higher operating costs per acre, higher cash expenses. Now we've left out of this table non-cash expenses like labor and capital usage, those farmers who observed a decline in glyphosate effectiveness also found themselves with higher labor and capital use costs per acre, they all add up to that bottom line which is a fairly substantial difference in net returns, net returns are gross revenues minus all costs and what we estimate there is a difference of if you look at about $22.50 per acre in net returns between those who had a decline in glyphosate effectiveness and those who did not so it works out to a fairly substantial, I would say, economic impact of resistance on farm financial outcomes. Alright, let me shift now and talk a little bit about what we've done in the report to analyze different stra, the economics of different strategies for managing glyphosate resistance. To summarize some of what we've done so far reliance on large amounts of a single herbicide, in this case glyphosate is believed to be the most important factor that underlines growing resistance of weeds, that spread of resistant weeds can be limited, now we don't believe it can be eliminated but it can be limited by using multiple herbicides that have different modes of action, by rotating different herbicide modes of action over time and by adopting certain other resistance management practices. To examine how these factors, the different herbicide use decisions might affect economic outcomes we used a Bio-Economic model to compare two different types of herbicide choices. One choice would be to manage glyphosate resistance and maximize long run returns, the alternative choice is to ignore resistance and maximize short run returns. Now let me take a little bit of time to say, to walk through in a little more, a little more precisely what we mean by that point. When we say that one is ignoring resistance in maximizing short run verses maximizing long run returns while one for ignore we mean they maximize short run returns by focusing only on the expected costs and returns for the coming growing season, the one immediately in front of you, the alternative strategy, one of managing glyphosate resistance and maximizing long run returns would

recognize that this year's weed management decisions affect yields in later years and will also affect expenses in later years and that strategy would attempt to take account in this year's decision making of those later impacts on yields and expenses, that's what we mean by maximizing short run verses maximizing long run. Now there are a lot of different ways one might approach a strategy of managing glyphosate resistance, in this model we take one very specific approach. What we call managing glyphosate resistance would differ from ignoring resistance in three important ways. First managing resistance would use less glyphosate, in particular would apply it in fewer years, second it doesn't apply glyphosate during consecutive growing seasons in particular, third it typically combines glyphosate with other herbicides. Now when we did a model to analyze the impact of managing resistance verses the impact of ignoring resistance we came up with estimates of returns that are summarized in this chart. What the chart shows is the difference for each year in net returns from a policy of managing resistance compared to a policy of ignoring resistance. We show three lines here, they're based on different crop rotations, the blue is a corn and soybean rotation, the red is continuous corn and the green is continuous soybean so under three different rotations strategies we're comparing the impacts on economic returns of trying to manage resistance in the way we're noted it compared to simply ignoring it and what we find in the first year is that managing resistance gets lower returns, notice each line is in the negative quadrant, those are lower returns in the range of 8 to 12 dollars an acre because one for, one bares higher expenses from mixing those different herbicides in an the initial year however the impact on out years, on later years yields and costs start to tell very quickly so that a strategy in managing resistance generates greater returns by the second year than a strategy of ignoring resistance and those greater returns are actually fairly substantial for corn and soybean and for continuous corn and notice that in years beyond that second year the gap between the returns from managing resistance and the returns from ignoring it grows fairly substantially and gets up towards 50 and 60 dollars per acre. So there are short run costs to be born from the strategy of managing resistance but our model indicates that those are quickly outweighed and there are some substantial long run gains in net returns from managing resistance. Alright, now earlier I mentioned the phenomenon of weed dispersal across fields, they migrate from neighboring fields. We looked at the question in this case of how joint management efforts between neighboring farmers might work. In particular we looked at the impact on net returns for managing glyphosate resistance when your neighbor also manages and when your neighbor doesn't manage and it turns out that the gain and returns from managing resistance compared to ignoring it would be grater still if neighbors are also managing resistance. This table summarizes the results of a fairly complex analysis, again, what we're going to

look at here is estimates of net returns per acre and we're looking at them under several different strategies, we're comparing them from what the neighbors strategy is for ignoring or managing resistance and what a particular growers strategy is, I've set this up for a corn, soybean rotation, these are the numbers that come out of that analysis, the report gives a lot more detail on other rotations as well. Start with the lower right hand corner the pink bar, our estimate there in a case in which both the grower and the neighbor are ignoring resistance is that the, the grower would get a net return of $311.77 an acre, give a little detail underneath of what type of net return that is all I'll indicate at this point is that is an average stretched out over 20 years converted to a present value and those future 20 years that we're looking out at are years in which we expect yields to continue to grow because of continuing genetic improvements so these numbers are fairly high but they reflect a period well out into the future. Alright, start from that base and ask ourselves what happens to our estimate of returns when the grower manages resistance but the neighbor doesn't? Notice the grower is better off, the growers returns jump into that yellow box, they get $336.19 and that is an improvement in net returns at $25.00 an acre, that's a fairly noticeable one however when both the grower and the neighbor are taking strategies to manage resistance the growers net returns jump substantially to $378.36 an acre and increase of more than $40.00 over the case in which only the grower is managing resistance at an increase of almost $67.00 an acre compared to when neither one is ignoring resistance. So what do we take out of this? Well the grower and the neighbor are each better off in the long run when they manage resistance, there's no conflict, there's no prisoners dilemma here, managing resistance is in each of their individual interests and so what's important is that they recognize their long term interests. I should add this finding holds for each rotation pattern and cooperation raises the returns for each. Alright, let me move to a summary of what we have in this report. First let’s summarize the main finding on the evidence, what we've learned about resistance the most important factor for the evolution of weed resistance in this analysis is relying on glyphosate alone for weed management. In support of that we have this big difference between soybeans and corn, we think of glyphosate resistant weeds as more prevalent in soybeans than in corn because first more glyphosate supplied to soybeans, second glyphosate was used on more soybean acres, third glyphosate was used more exclusively on soybeans and finally tillage, a mechanical method for controlling weeds without promoting herbicide resistance was used on a greater proportion of corn than soybean acres. The flip side of that is that more conservation in no till was used on soybeans. Finally in this summary resistance to glyphosate associated with reduced yields, with increased costs and with lower net returns. To summarize our main findings on managing resistance we find that managing resistance with a long run perspective can slow the evolution of

resistance and increase net returns to farmers. Our model increased one, emphasized one specific approach to that but there are others as well. We also found that cooperation among neighbor's matters both for controlling resistance and for the economic returns to investments in managing resistance. These findings suggest that a program of education could, to promote the use of resistance management practices could increase returns to corn and soybean production, that education should stress the economic cost of glyphosate resistance, the economic benefits of managing resistance and the potential benefits for cooperation among neighboring crop producers and finally at ERS our next steps in this cycle project are going to be that we have Phase II surveys going into the field for cotton this year in 2015, we'll be back analyzing corn in 2016, wheat in 2017 we will likely be back with our next Phase II soybean survey in 2018, we'll use data from that survey to support further research on glyphosate resistance and on the economics of managing it, I should add that we're also undertaking research with ARMS Phase II data on growth of resistance among insects to be peak crop variety. That completes what I have to say, do we have any questions?

James it looks like we have a question, does your model take into consideration the differences in seed costs when using conventional herbicides?

It does, I would for the specifics of it I'd have to say to take a look at our modeling in the report. I think that is a tricky issue for the future that was based, our modeling there is based on 2012 data, one would suspect that the price gap, gaps between different types of seeds would start narrowing if seeds are less affective in conjunction with herbicides and so it may be that those seed costs for herbicide tolerance seeds would be lower in the future, we did not explore that type of sensitivity analysis.

We have another question, why do you think that glyphosate was used more on soybean acres and more exclusively than corn, was that covered in your report?

We mention it in the report, it turns out in corn that there are other herbicides that are not very, that are not poor substitutes for glyphosate that can be used.

Glyphosate is a far more affective sub, herbicide than the potential alternatives in soybeans and so in a sense there are better technological substitutes in corn. One thing I'd think about for following up on that as well is that earlier chart that showed the spread of herbicide tolerant seeds in corn and that spread really didn't take off until the price of glyphosate fell so there is an important point to be made that some of that was a pure sort of economic substitution based on price differences but the short answer is there's just far more near substitutes for glyphosate in corn production.

Okay we have another question, do you think that the pros of using glyphosate verses another herbicide out weight the cons for the farmer?

Well I think that the pros of using glyphosate alone as a weed management strategy are getting more and more costly for the farmer and a key point of our financial analysis of alternative resist, managing alternative resistance strategies would be that what really makes sense for a farmer is using a combination of different weed control strategies and to avoid exclusive reliance on glyphosate.

We have another question, what are the different ways you can manage resistance?

Well what we focused on in today's presentation and in the report was alternative mixes of herbicides. Another way to manage it might be alternative combinations of mechanical tillage both for weed control and to manage the growth of resistance to glyphosate and different types of crop rotations can also serve to limit the growth of both weed resistance and certain types of weeds. We focused in this case to keep it simple on different chemical combinations but there are a variety of mechanical and rotation choices that can also work.

Okay we have a question from Kathy, for corn at least most GE seed is stacked with insect resistance is there a similar concern with insects resistant, insecti, do you account for the stacked nature of the corn seed?

Well in our data we have, we know whether the seed used was stacked and we also know whether it was only insect resistant seed as opposed to being only herbicide tolerant. We have some work going on now I think there is, I think it's fair to say that there is concern about the growth of insect resistance, I think that it does not appear to be as wide spread at the present time as the growth of resistance to glyphosate and we have research I expect will be publishing material in the not too distant future and be continuing doing some work on it but yes it's also an area of concern. I should add that almost, just about, well, any weed management strategy generates resistance and managing resistance is a key element and instead of just saying weed management I should say in general pest management.

We have another question, will new trait platforms included in the model such as dycam resistant or HPPD resistant soybeans?

I don't believe they were and I would say a reason for it based on the data we have is we didn't have much in the way of multiplatform traits available at that time in 2012 for soybeans or in 2010 for corn, that's certainly something that we need to pay attention to moving forward as genetically engineered seeds become more complex and more stacked.

Okay we have another question, have you or anyone else considered if frequency and impact of herbicide resistant weeds entering the United States through imported seed and grain?

We haven't at least in our team, I would say that's a broader question for the regulatory agency Animal and Plant Health Inspection Service, we can follow up a bit more on it but that's not something that we considered in the report.

Okay we have another question when did the Roundup Ready II Gene become part of the RR corn and RR soybean and was that a trait was that trait a factor in increased glyphosate use?

I would, you've got me there I'd have to go back and look that up I don't have the specifics available on it and I'd have to think a little bit about it.

Okay maybe we can provide the answer later.

Yeah.

Did the model take into account regional difference?

Yes, I did not report that in the presentation but there, but the report has some work on that and in particular, I mean it's a good question. The extent of, of reported declines and the effectiveness of glyphosate varied regionally and in a way you might expect, it was a more serious problem in more southern production areas and a less serious problem in more northern production area where we might be able to rely on freezes to do some killing for you but the report itself does have material on regional difference and there are some.

Okay it looks like that's all the questions we have, thank you all for joining us and I think we'll end the call now.

Thank you very much, thanks for the audience.

Have a great day.

Bye, bye.