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Thanks, Paul and thanks Leslie. It's a pleasure to be part of the

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soil health cafe and everything.

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We hope that or I hope that as any cafe you get an opportunity to feast from the buffet.

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From that standpoint and and see what we have and all of this, but, you know, it's, it is my pleasure to be here and I do want to talk about soil health and and increasing productivity and profitability, all those different pieces that are in that aspect

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and everything and so when we

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If we think about soil health and I'm going to relate it back to the soil functionality. From the standpoint that.

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And all of this. When we think about the different functions of soil.

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We need to think about the the functions of being able to provide support for plants. We want our plants to stand up. We want to be able to traffic across that field. We want to have the soil serve as a water reservoir that supplies all the water that that

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00:01:20,600 --> 00:01:38,600
plant needs. We also want it to be a nutrient source for plants in terms of reservoir for promoting plant growth. We also in this in the current age you know we're thinking about what role does soil have in terms of carbon cycling and storing carbon and

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and mitigating climate change and all of this. But then there's other functions in terms of the decomposition of pesticides, antibiotics that are our function of what biology goes in that.

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But if you think about the soil health piece and the functionality is a soil health is is or health is really how do we maintain our functions? I mean when you go to the doctor for physical checkup I mean they look at your blood pressure, they look at

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00:02:07,600 --> 00:02:19,600
your lung function all those different things. Well, same thing in terms of our health relative the soil and being able to provide these different aspects for all of this.

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And so if we go and think about our current state of the soils.

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It really is a piece of this and I'll just go back and show the long term effects of crop rotations and you know there's probably nothing more famous in the United States than the Morrow plots and the Sanborn fields and compared to, you know, Rothamsted

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has always been hold is that the the biggest aspect of long term experiments, but just look at the changes in organic matter

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hrough the through 1990, from the time that we begin to cultivate those. If you look at the continuous corn rotations versus for the Morrow plots. And in terms of the corn oats hay rotation.

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I mean we've lost 60% of our organic matter from where it was originally 35% if you had the, the rotation in there. The Sanborn plots dropped off very rapidly with 70% loss under continuous corn. Continuous wheat wasn't a whole lot better at 65%.

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So all of these become the places in which we think about that losing organic matter out of that and since organic matter is tied to functionality, it almost say well how what functions have we lost in that soil, to be able to do this?

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And if you look at your maps across fields. I mean, you know, we can look at these ad nauseum and all this but in reality, it's, it's really where water availability gets in this, that really

trumps our distribution of nitrogen and trumps a lot of this

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so water availability is the cause of this and this field here

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those orange spots are really poor soils in there they have limited water holding capacity, all these different things those brighter green spots are the much better soils with higher organic matter in all of this.

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So the question is what causes carbon loss from the soils? You think about that, the steam coming out of that cup of coffee you can think about that co2 going back to the atmosphere in that same way in all of this.

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So, When you think about these dynamics.

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We've looked at a lot of carbon balances and this is from one of our long term experiments.

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We've had a field that's been instrumented with these Eddie correlation equipments to measure co2 and water vapor exchange. We've had all the energy balance.

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We actually have had that since 1992 and it continues today.

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But we looked at a sequence from 2005 through 2016, because we had intensively sampled those soils. In 2005, we, we did it at 50 meter grids down to 1.2 meters.

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So we could get a soil balance and then we took these Eddie correlation equipment and looked at the carbon balance and you can see this in terms of the total season at the top or the growing season.

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And then what happened in the offseason, but the typical corn, soybean production system and this is deep rip in the fall, field conservation in the spring.

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There's no residue removal on this but the over that 16 year period, it was losing roughly 1000 pounds of carbon per acre per year. I mean, so that's a, you know, you say well that's only half a ton but in reality it is important in terms of where it changed

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00:06:02,600 --> 00:06:08,600
these dynamics. And so if we look at management of systems.

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And a lot of this is we removed it by tillage. When we till that in that deep rip in that field cultivation in spring is we see flashes of co2 go into our at correlation equipment so we can pick that up in terms of the fluxes that are out there.

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The other piece of this when you think about back to the Morrow plots and the Sanborn plots, is that those cropping practices like continuous corn or even a corn bean rotation limit to return a carbon into the soil.

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And so, intensive tillage and a more monoculture system.

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You know we just aren't putting the carbon back that we need to. And so the the impact of that is that we've reduced our functionality.

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We have reduced that capacity to store water. We've reduced the capacity to cycle nutrients. And then when we begin to degrade the soil without organic matter, we see increased erosion rates. We see increase soil degradation and all of this.

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So all of these have changed our soils over time.

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And if you set and look at a field over a 50 year period you can begin to see those changes. We see across the upper Midwest here that a lot of our low organic matter soils that are on top of our knobs around in the prairie pothole region have gotten bigger

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over time. They've grown about three times in size, over the last 40 years because we've taken the organic matter out of them.

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The other factor is that the primary factor and why water becomes important is that water is the major determinant of yield and so when we are either having ponded water and that uppercase there where

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we've drowned out the that crop. You know, we have excess water when we run it off, we were no longer infiltrating it into the soil and it's not available to us.

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So you think about this or this soil health piece is affected by reduced tillage.

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And so as we begin to manipulate the tillage we can change the soil health.

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You look at the soil health practices in terms of continuous cover on there, protecting against those raindrops. Cover crops, I'll talk about that a little bit in terms of how to, how do they begin to influence the system, how, why is adding crop diversity

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important in all of this? And even there's questions now what's the role of livestock, in all of this? Do we really begin to think about livestock as part of our cropping systems? And the use of bio based fertilizers, fertilizers that contain carbon

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manures, some of the other things that are with that in all of this. So it's really a carbon based fertilizer from that standpoint.

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And if you think about this. In reality of how we change soil health is really thinking about how we manage carbon.

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And if you think about this carbon energy flow path. I mean we're all in the, in the solar harvesting business with crops I mean we're taking sun, we're combining that solar radiation with co2 and water.

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We're creating a carbohydrate. That carbohydrate goes down to the plant leaves into the stems into the roots in the root exudates that feed the microbes, create the soil fauna, we end up in that soil fauna either influencing carbon cycling or nutrient

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cycling, all of these different pieces come together. And so in reality, this carbon cycle that we see in this diagram is extremely important to us and so it's a matter of how are we managing that carbon in terms of our flow relative to the system out

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here.

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And if you also think about what causes changes in terms of soil organic carbon is that you back and you look at these

functionality. At the first factor that causes these changes is how we manage our micro organisms and soil fauna.

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And then we get into clay content and then finally into land use and management, you know, and we just go down to and so these are in relative importance and so it really is how do we manage our carbon relative to micro organisms that are within the soil, and you think about

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this piece and then I put together this diagram a number of years ago, is that if we want to think about a grading soils or increasing the functionality of soils, is the first step on this ladder is biological activity, and to create biological activity

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within the soil is that they requires four things, it wants food, which is a carbon supply. It wants water, because all of us need water because that's life. Air it needs oxygen.

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If we take oxygen out of the system we change that whole biological system very quickly and shelter and basically because microbes don't like disturbance.

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Neither do any of us but you think about those four things are the same things that we want in terms of looking at this. So, as we promote biological activity we see this rapid turnover of organic matter. We see improved nutrient cycling.

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These are what I call the invisible and dynamic processes, you know we don't see them but they're they're occurring out there. But what we do see is we see improved soil structure, we see improved aggregates, we see improved water availability and all

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of this. So, we actually can see these changes within the soil.

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And these root exudates that are coming out of that carbon diagram. Interesting piece of this is that they're finding that it probably 15 to 40% of what's been fixed photosynthetically is exuded from roots.

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That's a large carbon source, and it primarily it is glucose and fructose and saccharose, and then ribose. And it's estimated that that 64-86% of that carbon goes back as co2, because it's getting recycled and the two to five percent is in soil organic

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matter, and then the rest of it's in those glues that are holding aggregates together.

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So these fates of sugar and soil is that they they helped form the aggregate.

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They help with carbon sequestration. They're the maintenance of microbial activity and function. So, these sugars as part of this photosynthetic process play a real key role in how do we think about soil health.

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And if you think about this from the exudate standpoint is that those microbes are feeding on exudates so I mean we all like sugar, let's admit it.

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00:13:05,600 --> 00:13:12,600
And that microbe takes those glues based on sugars and glucoproteins and that forms the aggregates.

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We just finished and results from experiment in which we were using a cover crop and a combination with a sorghum and wheat rotation and finding that we could change the aggregate size within 130 days, we'd already begun to see that change in the

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aggregate.

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And then we have co2 coming back off because microbes just like you and I. They take in oxygen and give off co2. So co2 respiration tests are why we see some of the changes in soil health.

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But if we look at different cropping systems and they think about this carbon input and and if you think about that crop during the middle of that season that gray bar on the left hand side is that a lot of our cropping systems have limited time for input.

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Limited time for growth and then they have losses due to tillage. And so the losses may equal the gains or exceed that the gains that are out there. But if we had that cover crop, that pink bar on the

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right side is that we increase the, the time in which we capture photosynthesis and we put that carbon into the soil, and we couple that with reduced tillage, reduced disturbance and all of this, we begin to see those changes occur within the

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system.

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So if you think about just from the water side.

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What cover does and, you know, the physical presence of cover on that soil surface.

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First, it protects against raindrop energy so that soil aggregates are protected, infiltration rates are maintained, we reduce the soil water evaporation rate.

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And so that plant can use that water for transpiration also we find that when we have that residue layer is that those roots are near the surface so they can take advantage of small rainfall events.

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We can do this within the first growing season. This is not a long term effect, we can change the water balance. As soon as we put that cover on that soil surface and and these become very important in a lot of this.

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And we just think about it from this standpoint.

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Here's the left hand side of this low biological activity, very unstable aggregates. Right side is high biological activity, very stable aggregate. As that raindrop begins to hit that aggregate,

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it begins to dissolve it, it goes into sand, silt and clay. These so particles that have moved down clogged up all the pores.

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That's where we see very limited infiltration rate, very fast times to run off. If we've got very stable aggregates, we're not dissolving that. We're not clogging up those pores. We keep water moving down into the soil, and so you know all this we see infiltration

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rates that are much different between soils that have higher aggregate stability and those that have low aggregate stability.

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00:16:12,600 --> 00:16:16,600
And really it's about how do we begin to manage that water system.

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So we think about this carbon balance in soils, is that we do have to increase the carbon content. We got to sequester, and we have to exceed the outputs, and since its a biological system,

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inputs must be in excess maintenance level for growth to occur. I mean, we gain weight because we eat more than we have expended in terms of metabolic energy and so it same thing in terms of biological system of we want that to grow, we're going to

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00:16:46,600 --> 00:17:03,600
have to begin to add additional carbon into that. I'm just going to give you an example as we finish up here from a farmer I've worked with up in Mitchell county Iowa. It's Wayne Frederick. Wayne started no till soybeans in 1992.

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He then switched and added strip till corn in 2003. In 2010, he began to experiment with cover crops, in 2012 had it in all of his fields.

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And we've, we've done a deep dive on on his data over this period of time.

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Here's this organic matter changes that have occurred. This red bars when you begin to introduce the the no till into beans and the strip till into corn.

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You see that we've had about a two and a half percentage point increase over those 25 years, the fence rows that we sampled there somewhere between six to 9% so you can see we're getting close to what it was originally; not there yet

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and all of this. But what we have seen, and is that we went back in the yield monitor data and we segregated by the soils within each of those fields, we had yield monitor data from 2003 to 2016. 2018 I'm sorry.

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We analyze that by individual soils within the field.

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This is just on corn.

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This is for a field that has Ostrander loam in it. You see, what we did is we begin to change the skewness and kurtosis. We were changing that yield distribution within that soil, and basically removing the low yielding parts of that. We were

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making the field more uniform, because we were increasing the capacity of that, that soil to perform.

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Basically supplying water and supply nutrients. We see it also in Franklin silt loam and all of this. So, we see these increasing uniformities.

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But then there was another thing we looked at it because as we look at this changes that when we looked at Mitchell County, we find that the county average yields are negatively correlated with April and May rainfall. The more it rains in April and May the

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lower the average county yield.

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Because we would delay planting. We put excessive water stress on that plant early in the season, but in Wayne's we haven't seen that correlation since 2015. it's.

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He's able to plant on time. You see all this.

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The other piece of this is that yields are positively correlated with July-September rainfall, the more it rains in those months.

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You know we see higher yields because that's the high water use period and that's where we see the effect of these poor soils within fields.

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And so, you know, we don't see that correlation again because he's got that extra water stored within that profile. What that's done for him is that from 2004 to 2018 on one of those fields, there's a 41% increase in water use efficiency.

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We had more yield per amount of water that was falling during the growing season.

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Another field almost a 50%. Soybeans were about a 26%. The other part that's that last part in there as the profitability of that field is is increased, because those fields and become more uniform.

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We've taken off the parts of that field that are costing money. We've taken those low yielding parts, each soil out made them much more in all of this.

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So we, the other part of this is that really hasn't increased the nitrogen input over time so fertilizer use efficiency increased. There is a been a decrease in phosphorus and potassium inputs because of that cycling. Has more timely

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00:20:42,600 --> 00:20:58,600
operations because he has better trafficability. And all of this. His yields and become more stable. We don't see the variation among the seasons, actually has less risk-based programming, Wayne has actually changed his crop insurance portfolio.

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And then he's increased his profitability

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across those fields as well because again we're taking those low

yielding parts out.

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So the implications of all of this is that soil health allows us to utilize precipitation as transpiration.

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We're getting that water into the soil, making it available that plant. The increases in aggregate stability give you better infiltration of water and gas exchange, keeping that the microbial system supplied with oxygen.

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We're increasing field uniformity because we reduce the low yielding areas of the field, and we decrease the yield variation. And so we, in essence, we increase the profitability of that field as well.

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And so, you know, we leave a lot of this and we we talk about all these different things but as we start thinking about soil health relative to functionality: supplying water, supplying nutrients, supplying support.

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You know, we've improved the functionality that soil reflected in the productivity and all these different pieces. So with that,

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I'll leave this up while there's questions and everything Paul so that if anybody wants to get ahold of me.

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There's my email and there's my cell phone.

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If I don't recognize your number I won't answer.

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00:22:25,600 --> 00:22:33,366
But, you know, leave me a voicemail and I'll get back to you on that. I was tired of hearing about how I needed to extend my car warranty. So with that I'll entertain questions Paul.