Resilience research at University of Kentucky organic farm

The interview team had spent several days traveling through Eastern Kentucky talking to small farmers who have somehow eked out a living in an area where there is little arable land, even sparser supporting market infrastructure, but very resourceful and resilient growers. Now we were headed to the source of agricultural knowledge for many of these farmers. Our last morning in the hills began with riding dirt paths between small pastures in the mountains but as the day went on the roads got wider, the land flatter and the fields bigger until we were on a six lane urban commuter highways lined with malls, megachurches and fast food chain stores. After such a long time in the backcountry, this was an almost visceral shock, the crew was in alien territory. We were enduring this shock to try to find University of Kentucky organic farm.

In the midst of the traffic and suburban sprawl, our navigator said, "We're really close, it's just around the corner." At the next intersection, with new malls springing up on three corners, the fourth corner was covered in huge clumps of tall grasses. These were Miscanthus--a very hardy, aggressively growing, thick-stocked grass which may soon become the next wave of biofuels. After a quarter mile of Miscanthus, we turned into the midst of it and a locked gate opened automatically for us, thanks to .Mark Williams, the mind and energy behind University of Kentucky's Sustainable Agriculture farm.

We pulled down the lane and took an easy breath as the Miscanthus gave way to apple trees, research plots, high tunnels, tractors driven by young people with wide-brimmed hats. An agrarian refuge in the midst of the glitzy ephemera of suburban excess.

This little oasis has a long history of farming. Archaeological studies have shown evidence of agricultural activity dating back 10,000 years. It was purchased by the university in 1956, one part of a very large, very old farm by the name of Waveland. It's namesake comes from when it was full of hemp, waving along in the wind. It was originally a slave-managed 2000 acre farm, deeded to the Bryan family, its first owners, after the revolutionary war. It came into trouble after the civil war, and has dwindled in size ever since. As the town of Lexington encroached, the farm was sold off in auction section by section. It was, before the tracks were erected for the world-famous Kentucky Derby, Kentucky's first horse racing farm. Luckily, the university has developed one of the most forward thinking agricultural programs, and all of this beautiful silt loam soil isn't going to be compacted under parking lots any time soon. 100 acres remain to be a research station on the front lines of American sustainable farming.

We made our way to the break room/classroom/kitchen building. A small structure with an open front end. There, Mark Williams was awaiting our arrival. We shook hands and made our way to the table, there was an intensity and focus in his eyes and demeanor that we hadn't seen in Eastern Kentucky farmers. Some of the intensity though, as we found out, was due to the fact that this has been one of the most erratic and difficult seasons of his career and every day that the sun is out is time to be moving along...and move we did, over a vast swathe of conceptual territory in a very short timeframe.

Mark mentioned the name of the road that we came in on- Emmert Farm Lane. It was named for Dr. Emery M. Emmert who had pioneered plastic mulch and other used of plastic here on the South Farm. It was his development of the high and low tunnels and plastic covered raised beds which has lead to longer seasons, higher yields, and greater viability of veggie and specialty crop production. Along with no-till agriculture, his are one of the two foremost contributions of University of Kentucky

to modern agriculture.

In 2000, the farm was divided into conventional and organic agriculture sections. The goal is agricultural sustainability. "When you approach farming from a sustainability standpoint, the difference between organic and conventional from a technical standpoint becomes almost insignificant." Mark said, going on to clarify- reminding us that in both techniques, they use the same boom sprayers, fertilizer hoppers. Here they also used the same integration of cover crops and rotation, soil fertility management, minimal tillage. The very same techniques, just different chemical applications.

This is a highly mechanized farm, they've traveled the world for more than 15 years studying other organic farm operations with three key questions in mind:

"Can we make good money farming? Can we have a life? Can we feed people healthy food?"

Mark sees a big part of Eastern Kentucky's poor health and poverty to be a number of things. Much of it is diet and lifestyle choices...but the historic farming system has been of little help. Historically, farm production in Kentucky has been tobacco, livestock, corn, and soybeans. These are all sold on commodity markets much of the time going to other regions. The poorer it gets in Kentucky regions, the worse the health is. Food deserts are bigger, farms get tinier and tinier...and he sees it as a self-perpetuating system. Unless you have a really, really massive operation, it is very difficult to make it in agronomic crops. "Some of the interns come from agronomic farm backgrounds. 4,000 acres, 30,000 acres. They're still struggling. How can a young person go into an agronomic system and be able to be competitive with the really big people?"

This research farm is a proper response to that- they are developing farm methods which can be profitable over a multitude of scales and applications. The KU research farm is broken into sections:

1.-Viticulture, Distillation, Wine, and Brewing; They have 7 acres of vineyards and orchards to produce hard cider. Kentucky being the home of whiskey, it's only natural to research farming for fermentables.

2.-Commercial landscaping produce.

3.-Biofuels- Remember the Miscanthus? They are working for a self-sustaining energy future for the farm.

4.-Commercial produce, which is split into two sections; organic and conventional- both of which are managed using sustainable practices.

30 of the 100 acres is set aside for organic farming research. 15 acres is used for USDA and federal grant funding. This is where they work on a full systems level in high tunnels, specific pest/crop systems, finding ways to eliminate the threat of cucumber beetle squash bugs, all the way down to " 'basic' science" as Mark says.

Some "basic" science indeed. They spend lab time looking into the plant microbiome. The few years have seen a revolution in molecular biology that will change the way we look at resiliency of agroecological systems. They have developed next generation gene sequencing techniques influenced by projects where scientists are mapping out the human microbiome. They can now do mass

sequencing of mixed populations of genes in a mixture. With this, they can identify different species as well as sequence genomes of these different species in a mixture.

Certain plants such as legumes and clover have associations already with microbes; the nitrogen producing rhisobia. Micorrhysal fungi have also been well documented in soil systems...but this is only a snapshot. It has been found that plants have same microbiome as humans do. It goes through every part of system- from leaves, to stems, and on to fruits. We eat these plants and inoculate ourselves with these same microbes.

Sustainable practices for soil management like organic farming that reduce the use of bacteriacides, fungicides increase soil microbial community structure development. The word organic in organic farming is telling of this. The main focus of successful organic farming is on organic matter management, which is the food of the soil. "It has been well documented that when you increase microbial community structures, functions, evenness...it increases level of activity in the plant's microbiome. When you farm in a way that increases the soil microbiome, it also goes into the plant and gives it the ability to resist disease, insects, drought." They are just scratching the surface on how these these microbes change the genetic expression in the nucleii of different parts of the plant and affect the overall health of the farm system.

They published their first paper on it last year in 'Frontiers of Plant Science' where they looked at four different crops which were either organically grown and conventionally grown. They showed that there were statistical difference. If humans eat antibiotics, it kills our systems- the same thing happens with plants. "When we treat our soil in a way that kills things, there's a price that comes with that." This has implications for drought tolerance, climate disruption, and many other things and is a justification for thinking about farming in a way that enhances biological processes in the plant. Biodiversity of organic systems has long been a focus of Organic farming..but it has historically been hard to scientifically show until recently. Really good organic farmers are religious about soil management. Beyond just the roots, microbes are circulating in plant. Just as in humans, where our body is largely populated by bacteria and fungi of different types. So plants, humans, animals, all could be connected directly to soil microbe communities. Or at least they could be...Mark doesn't want to make definite assertions until a couple more years and a couple more research teams confirm their findings.

The other half of the organic unit was split off and used for their Sustainable Agriculture degree program. It's a four year undergrad program, where the student finishes with a bachelor of science. Students take classes in the three pillars of sustainability. Environmental stewardship-animal welfare, soil science, etc.; Economic Sustainabilty, and Social Responsibility which is manifested in studies of how to feed increasing populations of people healthy food while still meeting final cost accounting.

In addition to learning about these pillars, students also focus on a particular farming system- livestock, organic veggies, or any of the many aspects of rural production that KU offers both field and classroom credits for. Mark reminds us that they also want to reinforce that sustainability is a global phenomenon- so they have study abroad programs.

One thing that sets the KU Organic Ag. program apart from many studies is the emphasis on experiential education- teaching people to farm by turning them into farmers. They set aside land for a model organic farm so they would have a situation where people could see and actively participate in functional comparisons of both conventional and organic practices. They are looking at organic operations around the world and are building a commercial scale system, not a garden scale system-

which is what is seen in a lot of university settings where the students are offered organic production courses. They are more interested in building the equipment and capacity to feed a lot of people as well as to make good money on the operation. This is how they actually finance the program. In order to be able to offer such large range of study and practice, they had to be able to set up the operation on the precondition that they could fund it with farm revenue. They have a CSA for the organic section that runs for 22 weeks, they sell crops wholesale to UK dining services, and run 2 farm stands per week. It's enough to pay five people and provide revenue to continue the programming. Their gross sales for the last season for the CSA alone was $22,475 per acre with the 30 acres on the organic farming unit. It is a highly mechanized system, with their labor cost being 42% of gross sales...which isn't too bad for a farm.

They have 20 student apprentices and some 200 people in the CSA; all within the UK system of faculty, students, and staff. They only have the farm stands on UK campus. They've decreased their competition by keeping it in the UK family. In terms of scale, they have the mechanization to farm much more than they actually do. Their goal is to have a system where they can teach people what is possible in the state of Kentucky... which historically doesn't have this type of cultivation. From a large scale, to a much smaller scale where one would use European walk-behind tractors and hand tools. They teach both row crop systems and also high-revenue small plot systems.

As we sat in the shade and spoke through the drone of tractor engines and birds, we shifted the focus of our conversation away from marketing and science to one thing that detracts from the ability of sustainable farm practices to take hold in a place such as Kentucky. Mark reminds us that there is such heavy polarization and misunderstanding about sustainability and organic farming. "They (conventional/commodity farmers) associate organic farming with particular political parties, religious persuasions, and everything that they are not. To them, it's not associated with which type of pesticides one prefers- it is construed to be associated with a whole way of thinking about the world."

Many people haven't seen organic farms in motion. So many people who have all of these preconcieved notions of organic farming as something that new-age granola fanatics treat as a religion are surprisingly in support of most of the values of organic farming in practic. "When they are asked about whether they support systems which are harmful to small farms, or feeding people food that makes them sicker, they realize that they may support some of the benefits of sustainable agriculture."

It is harder for farmers to wrap their heads around the social responsibility, social justice elements of sustainable farming. It's easier to talk about soil health and crop diversity. Mark recalls that there was a bit of blowback from university agronomists when the sustainable agriculture program was being initially implemented. "They worried that if this program furthered sustainability education and practice, then it would imply that the all of the other curricula would be perceived as unsustainable." He says. It's a difficult and contentious discussion.

Mark and staff are teaching by example, showing students that sustainability can and should impact many aspects of their lives and business practices. "For us, it's not whether we are using a naturally derived BT or a synthetically derived BT...it's the way that we live our lives." The perfect and most immediate example of that manifestation is the farm shed we were sitting in. It was originally constructed in the 1950's. They've worked with students to get recycled, donated, or federal surplus materials to turn the old shack into a meeting area and kitchen. The structure, though reconstructed with little to no money from used materials, did not look like a random patchwork collage. The kitchen has nice stainless steel countertops and ample space to prepare meals on a commercial scale. Every Thursday, they have a big dinner. One of the requirements is students have to cook a meal for some 40

people with ingredients that are currently in season.

"Farming is knowing more than just putting plants in the ground." Mike says, as we get up and walk about the room. They not only teach crop planning, but also building techniques: carpentry, masonry, and welding among other things. The area is well lit not only because the front face opens to view the fields, but there are also nice windows for mid-day ventilation and passive lighting systems in the surrounding walls. There was an old light shade from an industrial light that was transformed into a sink. A cabinet mount was built around it but left open so one can see where a drain was connected where there was once a power supply. It has an old retro modernist look to it, many of the fixtures and furniture were salvaged whenever buildings around campus were gutted for renovation.

We went out the back door and rounded the corner to one of the adjoining equipment sheds where the newer cultivation attachments reside. There were two different attachments. One, which he called "the traditional Kentucky system" was a bedder with a plastic roller and drip tape mount. It's a fairly simple system which maximizes possible yield and eliminates the viability of weeds on the mound by sheathing the whole row in recyclable plastic. As small as it is, it is a quick and effective means of prepping fields for cultivation and only needs two operators. It was a system that was actually developed on the UK farm. They only use it on a small handful of their crops- tomatoes, peppers, cucurbits, eggplant, and their "you pick" section. It's mainly long-season crops they cover with plastic. Mark says they'll do an intersewn covercrop of teff or rye grass in the furrows to eliminate invasive plants in areas not shaded in plastic.

With only long-season and you-pick crops under plastic, the rest of the farming system is done on bare ground. Their fields are arranged in 50 foot wide by 300 foot strips. This enables them to get their booms and harvesting conveyors out to cover the whole field to minimize ground disturbance and also to ensure faster spraying and harvesting of crops. Their boom sprayer is 25 feet wide, so they can cover the whole block in a single pass and return. They can fit ten double-row beds in each field for their bare ground system. They run buried drip tape in both the plastic and bare ground systems for efficient and uniform disbursement of water to localized areas, delivering water to the root ball and not leaving much for weeds. Being on city water, it is also a major savings. It turns water into a weed management tool.

We walk a little bit further into the shed to see the second machine that is housed there. It is an articulated cultivator. Each little tine is on a flexible arm. At this farm, they do their best to only cultivate and disturb soil at about ½ to ¾ of an inch. So this attachment weeds right at root level without breaking up much extra soil organic matter. It's got little tined finger weeders to eliminate any weeds in the row without disturbing the crop. It can weed at three miles per hour, which beats out nearly any other method. Without the use of defoliants or other herbicides, it will clear weeds at 96 to 98%. There are three cultivation steps, this articulated cultivator being the last of the three. He promises that we'll see the first two cultivators as we make our way around the farm.

After spending a bit to wonder over the delicacy and durability of this cultivator, we started over towards another shed that seemed to be full of music and activity. As we made our way over to the source, Mark motioned over his shoulder to the high tunnels behind us. They have three movable, and three stationary high tunnels. High tunnels extend their growing season far beyond what would be possible otherwise. They are able to germinate seeds earlier as well as grow some crops further into the season than the weather would usually allow.

We continued walking and opened the door to the packing shed, the sound of feet shuffling on

concrete and music increasing slowly as the door opened. The first thing we saw other than a young worker in big yellow waterproof bibs was a cabinet covered in pictures assorted produce. These were pictures of every week's csa box from 2015-2016. All 22 weeks of 2015 and the last four weeks of the 2016 season. It was a beautiful illustration of not only their industriousness, but also the blossoming of seasons- with the boxes being populated initially with cold resistant greens but then slowly growing with the yellows and oranges of squash, and then reds, greens, purples as the summer season sets in and the heat of the long Southern summer days bring forth a multitude of crops. Mark reminds us of the website and tells us that every week for as long as the CSA has been in operation has been documented there with pictures. It was a perfect blend of old and new as the Eagles filled the room and young people brought colored bins from the produce trailer, onto the rollers, and down into the glistening stainless steel wash tanks, removing any bugs, dirt, or any other detritus that would keep them looking anything less than beautiful.

We made our way outside to the bright day, past the harvest wagon as he told us how much more quickly they can speed harvest with their conveyor than hiking it to a trailer. Not only is it faster, it saves people's knees and backs from the strain of repeated heavy motion. We made our way across the road and out to the field to a block that was completely covered in netting, with little hoops pushed into the ground over the rows. Each hoop had to have been less than two feet in height. Mark explained that there was a cucumber beetle that they have not figured out any appropriate chemicals to take care of. They use what is called exclusion, and have the whole plot draped in porous fabric that they can still spray through if need be. They can use neonicotenoids as well, but they have preferred Protek netting. It also protects them from bacterial wilt. They can get 92-94% of conventional yields without spraying. They've been working some eight years on cucurbits, and the Protek netting is one of the most effective methods of loss reduction.

Across the aisle, the crops were covered in a white powdery substance, kaolin clay. It serves to disrupt insect feelers and irritates them to a point that they have difficulty sensing things, so it is a very effective deterrent. Mixing the clay with neem doubles its effectiveness as a pest deterrent.

So many of the fields that they put in this season were sources of anguish because of relentless rain. They would get a clear day where the ground would be dry enough to get tractors in but it was still so wet that the soil was rough and clumpy. The tractor broke down on the day that they were putting in the plastic, so they had to use one of the older ones without precision steering. That coupled with new interns who have little to no farm equipment experience has made for some crooked, uneven rows. The plastic layer wasn't set for that type of tractor so they had to use another smaller plastic layer. The cultivators were still set for their standard layer so it ended up ripping a lot of the plastic. “Sometimes things work very well when you are farming, and sometimes it is a symphony of everything screwing up,” Mark said good humoredly as we looked out over the rows- some of which snaked together and apart at random intervals.

They are not the typical farmers, and mentioned as we saw some of the mowed furrows where most farmers would have bare ground during the summer. They put in very competitive cover cropping between the rows that they keep mowed to fix carbon in the soil year round. In their you-pick fields, they don't use legumes but in the others they make sure to intercrop legumes in the furrows to continually fix nitrogen to lower the amount of fertilizers needed.

They have limited land, so there isn't the space to be able to let any of the land lay fallow for a whole year, but they make up for that by only doing single season cropping in their plots. The summer

crops come off, and they cover crop. Though they are farming fairly intensively, there is space allowed during the year to be able to allow the soil to regenerate and build up more biomatter. They use a spader machine, which is the gentlest way to disturb soil. Once the soil is opened up, they'll use no-till machinery up until the next year where they plant again. They cover crop with no-till grain drills and flail mowers. So ¾ of the year they are in cover crops, regenerating organic matter and using seasonally appropriate plants to bring life and health to the soil. Rye, sudex, oats, vetch, peas, crimson clover, red clover; a whole arsenal of crops are used to allow them to outcompete any weeds and foster as much organic activity as possible. They compost at a rate of 10 tons of compost per acre per year. The cover crops set the cultivation schedules. The first cover crop that they usually till under the soil is the sudex. The second are the plots with oats, peas, and crimson clover. They all mature in April. The last fields they go in are rye and vetch, which matures around May. For crops that need additional fertilizer, they use a granular fertilizer... and rarely- and only on the super long-season crops, they do an in-line liquid fertilizer.

The whole organic section was under trees when they started. They didn't even have a tractor on the first year and had to use hand tools to clear trees and roots, clearing up about ¼ acre before they were able to secure a tractor and a chain to move things along more quickly.

In 2003, it was painfully obvious that tobacco subsideis were going to end. The USDA gave UK a special grant to set up a new crops opportunity center. They funded research projects to help tobacco growers transition to develop new crops and cropping systems. They did peppers and tomatoes in the warm season and cabbage in the fall, peppers being a high value crop that seemed feasible in the area. They made a point to find ways to use tobacco equipment to cultivate the crop and sell the crops on the local food market. The idea was to be able to mitigate the economic shock of the end of tobacco by teaching tobacco farmers to use the equipment and local markets that they already had access to. This was around 2003-2004, when local food wasn't quite the buzzword that it is today.

With the machinery and system they have, the have capacity to cultivate 50 acres. “At one acre, you can cultivate with hand tools. At two to five, you need a bit of equipment. Once a farm has reached about ten acres of cultivation, it is time to start investing in tractors and serious equipment.” Mark says. There are a lot of moving parts and a lot of different technologies at work on this little research and education farm. It would take a monumental effort to get it all written down for people to study. Fortunately, there is somebody tackling a task as beastly as building the one big handbook to rule them all. The program has a student who is working on quite an interesting thesis. She is creating a comprehensive manual on all of the farming methods employed on the research farm. This goes from equipment and general land and soil management techniques down to the particular crop. The seed spacing, seeder plate settings, planting speed, and every detail is outlined in this farm manual. She is also listing all of the equipment specifications as well as maintenance manuals. It is written so that it is not only descriptive of their operation, but it can also be used by other farmers on other farming operations. One of the five chapters in the manual is also an outline of the economics. Yields, additive and equipment overhead, labor, prices, and everything else associated with running the operation. They held stop watches out in the field and timed every aspect of the operation for three years. They know for example, that every tray of transplants costs $14.65.

In keeping with the spirit of transition, of upcycling and retrofitting old tobacco technologies and things that already exist around in farm systems, they have a lot of intriguing machines. We walk from the last row of organics in this area to one more stand of machinery. Before us is a $40,000 green bean picker. Of course, it was picked up for free. Next to that is a postal delivery van that they also secured without the use of any money and fixed it up into their CSA delivery building. It's in very

good condition now.

Next to the delivery truck was one of the most interesting contraptions- a spader from Holland. It's the best tillage tool they have. It's a rotary spader with cupped spades. As it rotates at a really low speed, it dips into the soil and drops it out of the back. It ploughs down to 11 inches in a single pass. It has a rotary on the back that churns the soil three inches down, so it gets excellent depth while still keeping nutrients at root level. They have to go slowly but it still saves a lot of time compared to the methods that they had previously employed. When they had first started farming at the plot, they only had a mouldboard plough which they drudged through the field. After that turned the soil over, they did three to five discings and a couple of field cultivation passes before the coup de gras; dragging a telephone pole through the field.

Next to the spader was an old tobacco transplanter attachment with two seats has dual carousels with little funnel brackets. It shoots fertilizer in the furrow and water in the planting hole and then drops seedlings. 2 plants every 1.2 seconds with vertical flat mounts. With 300 plants on a row, they are at top speed able to get a whole row of crops in the ground in 3 minutes. Three people operate it. One driving the tractor, and two people pulling seedlings from the vertical seedling flat mounter about as fast as their hands and eyes could go. It involved very little modification to use this transplanter for something other than tobacco.

We worked our way around this planter to spy "The Holy Grail of weed control." Two classic Kentucky tobacco cultivation tractors, Farmall tractors from the seventies. The engine is offset to the left so the farmer is seated over the very center of the row, looking down through an opening straight to the crop. They call it cultivision. The steering was so loose on the Farm-alls that you could move it a quarter turn without affecting steering. They were old machines, and not necessarily tailored for precision driving. Mark and crew wanted to change that, so they took it to their shop. The steering wheel was originally attached by a solid column, coming from the steering wheel to the front axle. They cut that column out and tagged the steering wheel into the hydraulic lines. They then went to an off-road Jeep outfitting store and bought a double-headed hydraulic cylinder that they attached to the front axle. They tied the hydraulic cylinder to a box and attached that to the steering wheel, and all of a sudden, they were looking at a precision steered tractor for under. The tractor was $2,300. "For $1,200 more we got a dedicated cultivating tractor that super-precision now." Mark beamed as we all looked on in amusement and surprise. "That would be an example of hot-rodding old technology."

It was time to see the other two main cultivators of the three. The last being the finger weeder in the shed. They had gotten another old tobacco cultivator from agronomic professor Bill Whitt. They cut it into components and reassembled it into an s-tine cultivator with two other attachments that go along the sides of a plastic row and turn, then replace the shoulder of a plasticulture row. For anybody who has ever farmed plasticulture, you would know how near impossible it is to weed the shoulders of the plastic rows without tearing the plastic all to bits...but this machine does it without a hitch.

And finally, the basket weeder when the plants are small and can't take many disturbances. It has two baskets on the front. The front sprocket is bigger than the back...so the back row turns faster. They are two rows of rolling baskets, as the front basket rolls up, it smashes and then throws weeds up. Whatever little weeds are left by the bigger front wheel, the smaller, faster basket picks up. There is a four inch gap between baskets to allow space for the plants to pass. There is also a roller set to smash the weeds. Four inches between components to allow for seedlings to pass seems like a lot, Mark reminded us...but that's tiny when you're mounted on top of a tractor rolling through a field.

“One of the hallmarks to me of what I would consider sustainable organic farming...is taking appropriate technology of the present with the wisdom of the past. It's using really high end ideas and putting them with solid concepts of rotation and soil fertility management.” They are developing an autonomous tractor system for the Farm-alls in the near future that can be linked to gps systems that can use gps lead electronic eyes to be able to do spraying and cultivation from remote locations.

One of the real breakthroughs that they have made in their bare ground systems that ensures that they have very few weeds without having to use hand tools is to use buried drip tape so they can cultivate right over the top of the drip tape without having to pull up the tape to cultivate. Using no till technologies and buried drip tape they can define beds with wheel tracks and but not compact or displace too much extra soil.

They know that 80-95% of weeds germinate from the top ½ inch of the soil. So using very low disturbance machinery, they can eliminate germinating weeds without bringing any more up. They have very aggressive cultivators that don't penetrate more than 1 ¼ inch.

Because of all of these systems they are able to build enough natural fertility to only have to use granulated additives. As mentioned before, there is only one exception; long season crops they use in-line liquid fertilizer that has a hydraulic pump that they can work nutrients right down to the root ball. One of Mark's critique of normal organic farms is that they grossly under-fertilize...but most of their fertility doesn't come from spray tanks...it comes from living matter that they build up over time. That's why they've gone from 2% fertility to almost 5% in places...reaching nearly the upper limit. Especially with a system that cultivates all of the land every year, this is a remarkable thing.

With the souped up and ultra-modernized old equipment, the cover cropping plans, watering systems, and rotations that we saw, there were only a few questions to be asked...and of course those bases were covered in their systems. When asked about beneficial insects, Mark rolled out the arsenal. Aphids under the pro-tech netting, bumblebees in cardboard hives, ladybug releases. They also grow quite a few flowering plants to attract beneficial insects and are constantly scouting to make sure that there are plenty of native beneficial insects present to aid in pollinations and to eliminate predators.

We had made a tour of all of the annual organic crops, but weren't seeing any perennials in that sector. Mark assured us that perennials were covered. They've done grow trials with apples, paw-paws, blackberries, blueberries, and raspberries. Apples are the hardest thing for them to cultivate. So many chemicals have to be employed because Kentucky is becoming more and more of a temperate rainforest.

We went back to the main station for water and to say our goodbyes. Mark had way too much office work to be doing for such a clear, warm and sunny day. You could tell as we made our way through the fields that Mark Williams had reconciled the scientist and farmer inside and through that had greated a very ambitious and progressive synthesis. Dr. Emmert had made University of Kentucky a hub of farm innovation in the 20th century, and it was comforting to see that the torch had been passed.