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Regenerative Agriculture and Implications for Agriculture, Food, and Natural Resources Education

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It is a distinct honor to speak to you today about a topic I consider one of the most important agricultural movements occurring and its implications for our profession – regenerative agriculture. I was asked to speak on this topic last year in Michigan but was given 5 minutes and five slides – unfortunately for you Dr. Newman did not give me the same constraints for today, so you get the full enchilada. However, in doing so I am reminded of the three types of fun a California rancher recently described for me. According to him there is: Type 1 - fun at the time and fun to remember; Type 2 - not fun at the time but fun to remember; and Type 3 - not fun at the time and we're not ever talking about it again. I am planning on this talk being Type 1 fun.

My path to becoming an agricultural educator was an accidental one. I went to UC Davis with every intention to becoming a diversified livestock rancher in California. Even that path was not a typical one as my father was an anti-trust attorney in San Francisco and I grew up in the Bay Area. However, several life events steered me toward agriculture. My fifth-grade teacher, Mrs. Max influenced me when, as a class, we raised chickens as a class project. I soon had a flock of my own chickens at my suburban house way before it was the trendy addition to a Bay Area yard. My Dad was surprised that summer when he found out he had to take care of my chickens (which he knew nothing about) when I was back in Michigan.

Both my parents were from Michigan with agricultural backgrounds. I now live on the land my mother was raised on which is 1 mile from the farm my Great-Great Grandfather homesteaded in 1873. It is still farmed by my family and just down the road from the farm my father was raised on. From an early age I spent summers in Michigan working on family farms which influenced me to want to have a career in agriculture.

I mention my background because it is becoming more typical of our students who become agricultural educators as more of them are following a non-traditional path such as I did. Many of our pre-service teachers at Michigan State were not raised on a production farm or ranch. Consequently, many of them lack a depth and/or breadth of agricultural experiences to draw upon as agricultural educators. Given my goal of becoming a diversified livestock rancher I looked for every opportunity to gain experience that would help me toward that career. Fortunately, those experiences were also beneficial to becoming a high school agriculture instructor.

I worked on my family farms in Michigan, as a cowboy for Newhall Land and Farm, a packer/guide for Rock Creek Pack Station, a tractor driver for Fortiss Ranch, student shepherd at the UC Davis Sheep Unit, and a field manager for the UC Davis Polo Club to name a few. Through these jobs I learned how graze, shoe, weld, rope, tie knots, run a chainsaw, build fence, maintain and repair equipment and most importantly become a life-long learner who could solve problems.

Concurrently, I was doing everything I could to prepare myself academically. My Bachelor of Science was in Plant Science with an emphasis on agronomy. However, I took as many animal science related courses as I could take in addition to any other classes I thought would help me ranch including

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field operations, hydraulics and farm management. This was during the era where the message from the Secretary of Agriculture was "Get Big or Get Out". When I graduated that was the lens I was looking through. In my mind there was no way I could become a rancher because economically it didn't make sense. This mindset was the result from working on big ranches, graduating from one of the best colleges of agriculture in the world and the agricultural policies of the land. So, I became an ag teacher.

When I taught high school agriculture in the central valley of California, I concentrated on the intersection agriculture and education using everything I learned at UC Davis about agricultural best practices at the time and how to teach high school agriculture. Over the years, as my hair has gotten grayer, my worldview of an ag educator as evolved based on life experiences.

When I first started teaching, I was a certified Pest Control Advisor and I remember a farm where I worked, we were using ethylene dibromide as a soil fumigant for nematodes on tomatoes. The applicator was in a full hazmat suit as this soil fumigant was a Category I and marked DANGER. I had one of those "ah-ah" moments where I realized that something that was so dangerous, we had to wear full protective suits we were putting in the soil where we were growing food. Not surprisingly it is no longer labeled for that use because it was found in groundwater and it is now labeled a cancer-causing agent. Jump forward to when I was at Mississippi State in 2005, even though we were five hours inland Katrina was still a Category 1 hurricane when it hit Starkville. Parts of Mississippi became a Global South country over night. In Starkville grocery stores were stripped bare, gas stations ran out of gas and large sectors of the county were without power for weeks

It was through these and other life experiences I realized that our food system is increasingly vulnerable. Although modern technology has elevated most peoples' food security and material wealth, this has occurred at the expense of natural resources upon which humans ultimately depend. We now have a significantly degraded resource base in which the availability of quality soils, water resources, and other essential inputs are threatened (Hodbod & Eakin, 2015). Additionally, industrialization and consolidation has increased food value chain interdependence with other systems such as energy, decreasing the resilience of food systems to economic, environmental, or social shocks from the local to global scale. Agriculture must therefore be adaptive and able to address environmental, social, cultural and economic complexity, while being alert to unintended consequences.

This evolution has brought me to where I now view myself working at the nexus of agriculture and food systems, the environment and communities with a focus on both formal and non-formal educational systems with an eye toward food security. Consequently, if I were to go back and teach high school agriculture now it would look a great deal different then when I did in the late 1980s.

I believe the hardest thing to do in the world is to grow or raise food while at the same time regenerating ecosystems processes. Sustaining our natural resources does not go far enough, we need to regenerate our soils and the overarching ecosystem processes that determine the health of our land.

One of the best in-services I have ever attended was when AAAE met in Lincoln, Nebraska and I learned about StrengthsFinder (Rath, 2013). My number one strength, as was the case for many in attendance that day, was "learner". Fortunately, I picked a profession that aligned with my strength. The older I get the less I know and the more I want to learn. I have been fortunate to be in a profession where I am able to be in the company of smart people. Seneca captures this philosophy well in the following quote – "associate with people who are likely to improve you. Welcome those who you are capable of improving. The process is a mutual one: men learn as they teach".

One of the life hacks I have learned is when I have a conversation with these brilliant people, I have interacted with is to ask what the most important books in their library are – the first ones they would save in a fire. Here is the list of books that I have "stolen" over my career that have fundamentally changed the way I view agriculture and food systems (Table 1). With a show of hands how many of you have read two or more of these titles? What is revealing is that knowledge in these titles is not new, in fact one of these books was written nearly a century ago. Only two of them were written in the 21st Century. I have Kuhn's Structure of Scientific Revolutions at the top because I read it as an undergraduate and it helped me to learn to question scientific norms.

Table 1

Books That I would Steal

Title	Publication Year
The Structure of Scientific Revolutions	1962
Holistic Management	2016
Holism and Evolution	1929
Collapse	2013
Agricultural Testament	1940
Unsettling of America	1977
Pleasant Valley	1945
Sand County Almanac	1966
One Straw Revolution	1978
The Chalice and the Blade	1988
Don Coyote	2004
Call of the Reed Warbler	2018

The Kuhn Cycle depicts five phases with a sixth, pre-science, outside the cycle. If you feel you are solving your most difficult problems, then you are in Normal Science. However, if you are becoming less able to do so then you are in Model Drift. Model Crisis is the phase you want to avoid because you are failing most of the time. When in this phase you need to move quickly in order to get back to normal science. If you are a researcher though, this is difficult because to do so you need to redesign your core assumptions and change your habits and values which is threatening to you and your organization. The way forward is enormous change, and this is the Model Revolution phase of the cycle. This is your opportunity to step outside the box and seek out different contenders for a new paradigm. Don't worry if these contenders are in direct opposition to your core assumptions as this is what needs to change. When you are in the new paradigm it is obvious although not everyone will be there as some will feel threatened. I spent time on this book because it provides an outline for the remainder of my talk.

These examples of systems fall into two categories (Table 2). They are either complicated or complex systems.

Table 2

Complicated and Complex Systems

Complicated Systems	Complex Systems
Planes, cars, trains, ships, etc.	Croplands
Radio, television, telephone, satellites	Rangelands
Weapons: conventional, nuclear, laser	Forests
Spacecraft	Air Quality
Computer, robots	Fisheries

Table 2

Complicated and Complex Systems Continued…

Buildings, homes, churches, factories	Water supplies and quality
Roads, railway lines, bridges	Economics and finance
Home appliances, swimming pools	Wildlife
Clothing	Institutions/organizations
Dams and power stations	Human relationships
Medical technology	Human health
Chemicals, fertilizers, pesticides	

Everything humans make, which always involves some form of technology, lies in the realm of "hard systems." The things we make do what they are designed to do: the watch tells us the time, the computer computes. They do not do anything unplanned or unexpected and they are not self-organizing – they generally won't work if a part is missing, a battery goes flat or fuel runs out. They are complicated, rather than complex, and the problems associated with them can generally be solved, given enough time and money. Allan Savory (2016) points to the ever-increasing success story of modern systems testifying to the marvels of technology - if we ignore effects on the environment.

The things we manage, on the other hand, always involve people and human organizations (referred to as soft systems) or natural resources (natural systems). The things we manage in both soft and natural systems often produce unplanned or unexpected results and they are self-organizing: if a person or a species dies, the organization or the biological community adjusts and continues, albeit in changed form. The classic example of a complex system was the study published by Robert Paine in 1966 where in a tidal pool he eliminated a starfish that was a keystone species – within a year the number of species in the tide pool had been cut in half – a self-organizing system with unintended consequences.

These systems are complex, and the problems associated with them are called "wicked" because they are almost impossible to solve. It is this complexity that has made soft and natural systems so difficult to manage, leading so often to disappointing results and unintended consequences. The global food system is prime example of a complex system combining both social and natural systems. Global climate change, genetically modified organisms (GMO), water resource management, biofuel production (corn to ethanol), air quality, animal welfare, healthcare, soil erosion are wicked problems that have direct implications for food and agriculture systems with global climate change at the head of the list.

Batie's (2008) description of wicked problems includes the characteristics of a multitude of interdependencies and causations. For example, climate change, there is no one cause. Furthermore, there almost always unintended consequences to solutions – look no farther than Asian carp knocking on the door of the Great Lakes or Kudzu in the Southeast. Wicked problems are hard to define as they are constantly evolving and are socially complex – it is hard to define climate change when the President of the United States claims it is a hoax. Since they are multi-causal, they are rarely the responsibility of one organization and most importantly they involve changing people's behaviors.

Batie (2008) argued that linear science is not well positioned for solving wicked problems due to their characteristics, especially the conflict over values regarding the outcomes. Since they are not the responsibility of one organization, they do not fit into one discipline readily. Consequently, many disciplines must be involved, and stakeholders must be brought into the equation due to conflict over values. Going back to Kuhn's Cycle I would suggest we are in model drift regarding agriculture and its implications toward climate change.

Climate change is the most significant problem facing humanity. Greenhouse gases continue to accumulate in our atmosphere. The major contributor to this increase is the burning of fossil fuels during the past 150 years. However, the loss of soil carbon is also a significant contributor to the steady increase of atmospheric CO2. When I first taught *Introduction to Sustainability* in 2012 there was 391 ppm of CO2 in the atmosphere with models then predicting a 2 ppm increase annually. This is within the context that 350 ppm is the recognized level where systems start to tip. An example of a positive feedback loop is the thawing of permafrost in the artic – as permafrost thaws methane is released. Methane is a potent greenhouse gas with a global warming potential of 21 – meaning that it has 21 times the potential for warming the climate than does carbon dioxide. Hence the system begins to tip with a continued increase in temperature resulting in more permafrost being thawed further north and releasing more methane. When I created this slide deck it was 414 – an increase of 23.5 – an increase of more than 3 ppm annually. It is now over 415 - up nearly 1 PPM since I started preparing this lecture, now the highest in human history, it has risen 50% since the beginning of the industrial revolution and the highest in the past 3 million plus years. To deny climate change is to deny science.

Concurrently, climate change adversely impacts food security across all four dimensions (food availability, food accessibility, food utilization and food systems stability) (FAO, 2008). Agriculture and food systems are not only impacted by climate change but also contribute to it. Current management practices of agricultural soils account for over 50% of agricultural emissions. Soil erosion continues to be one of unintended consequences of how we manage our agricultural systems.

The 1930s saw the Great Dust Bowl and the havoc it wrecked on agricultural systems in the Midwest. Soil conservation became a national focus. Franklin Roosevelt famously said, "A nation that destroys its soils destroys itself". However, soil lost continues to be a wicked problem globally. It impacts all landforms and is interconnected to the grandest environmental problems we face. Diamond's (2013) book *Collapse: How Societies Choose to Fail or Survive* looks at the fall of numerous civilizations throughout history and their common thread is the depletion of their natural resources.

Half of the world's land is dedicated to agriculture with 1/3 of this land in cropland and 2/3 in grazing lands (USDA, 2001). On those lands there is over 75 billion tons of soil being eroded every year. That is approximately 10 tons for every person on the planet. If you assume the average American eats 2000 pounds of food per year (USDA, 2018) that works out to 10 pounds of soil loss for every pound of food eaten. I would argue that when it comes to soil, conventional agricultural systems are in the Model Crisis phase. Soil health is term that is being more widely used. When I was a Plant Science major, I took more than a few soil science courses – all those courses concentrated on almost exclusively the chemical aspect of soil. I have learned more about soils in the past few years from my work in regenerative agriculture than in all of those courses.

This image from Kenya is an example of poor soil health and what happens with continuous stock grazing resulting in overgrazing and non-functioning ecosystem processes – specifically the mineral cycle, water cycle, energy flow and community dynamics (Savory & Butterfield, 2016). The picture was taken while headed south on a November 2017 morning in the Mara National Reserve. On the way back these images show the results of a 2.5 cm rain event with extreme amounts of runoff and massive soil erosion. Nature abhors bare soil. NO where in nature will you find bare soil except in a true desert (which there are very few although we are doing our best to make new ones). This gully was dry when we drove through it on the way south to Talek – on the way North this is the result of the rain event with water flowing across the floorboards of the Land Cruiser. No water going into the soil, precious topsoil going down the river and continued degradation of the land.

Livestock is the other significant contributor to agricultural emissions (EPA, 2018). Overgrazing as well as enteritic methane are both factors. There have been a number of high-profile reports like the EAT-Lancet Commission (2018) that focus on the adverse environmental impacts of ruminants. However, rather than being a source and a cause of the problem, agricultural ecosystems can be a sink of atmospheric CO2 and reduce greenhouse gases (GHG) through the adoption of regenerative food and fiber systems.

I first heard about Allan Savory and Holistic Management from my cousins that run our family homestead. They have been practicing holistic management since the late 1980's. I have been fortunate not only to have read his seminal book on Holistic Management but to have numerous conversations with Allan on ranches and farms both in Africa and the United States. He contends and I agree that "the only wealth that can sustain any community, economy or nation is derived from the photosynthetic process - green plants growing on regenerating soil".

Holistic management has an over-arching framework that provides land managers the tools and strategies needed to manage complex systems while taking into account environmental, social and financial factors both in the short term as well as the long term. (Savory & Butterfield, 2016). Allan founded the Savory Institute that oversees the Savory Network consisting of 43 hubs with a short-term goal of 100 hubs. The Savory Network is global community working to advance regenerative agriculture. There are currently 10 million ha under holistic management and 9,300 holistically trained land managers. In 2015 Michigan State University was the first university to become a Savory Hub.

Allan developed Holistic Management out of necessity – going back to Kuhn's Cycle he was in Model Crisis. He was a consultant and ranchers were suffering financial losses due to non-functioning ecosystem processes. He had four insights that led to the Holistic Management Framework and the classification of tools that can be used to manage land. These tools are neither considered positive or negative – they are tools. It is how they are used when managing land that determines if there are negative or positive effects. Animal impact is one of the tools used extensively by holistic managers in the form of holistic planned grazing to regenerate land.

Kraals are used for several reasons. The main reason is to concentrate animal impact on land that needs it the most. In Zimbabwe they also use it for protection against predators. The herders push the cattle, goats, and sheep into the enclosure with exceedingly high stocking rates over night. The kraal is moved every couple of days to provide more impact in the form of urine, dung and trampling to the next section of land that needs it. This practice mimics the vast herds of large ruminants that co-evolved with the grasslands of North America and Africa. Colonel Dodge in 1871 estimated a herd of bison that was 25 miles across and 50 miles long with an estimate from anywhere from 4 to 12 million (Shaw, 1995) – the picture on the right would be our best guess of what the landscape might look like this after passing through. However, the bison might not comeback through again for a year allowing a long recovery period. This is how the grasslands of the world evolved - alongside vast herds of large ruminants.

Here is the result of animal impact from using a Kraal by the Sizinda tribe in Zimbabwe. Picture on the right is where the kraal is currently being used and shows animal impact. The picture on the left is where the kraal was previously - you can see the flush of green growth after a rain. The Sizinda tribe has been practicing holistic planned grazing for approximately 4 years when this picture was taken in 2015. The main river that use to stop running during the dry season is now running year around.

This photo of the paddock at the Africa Centre of Holistic Management at the beginning of the dry season where holistic planned grazing is practiced shows an abundance of grass. The next picture was taken the following day 20 kilometers away at the Zambezi National Park where no livestock grazing is allowed. The land is overgrazed by wildlife and the ecosystem processes are non-functioning due to the adverse impact of overgrazing and lack of management resulting in bare ground with no grass left for grazing during the dry season.

"Land, then, is not merely soil; it is a fountain of energy flowing through a circuit of soils, plants and animals" this quote from Leopold's (1966) – *A Sand County Almanac* captures White Oak Pastures' farming philosophy. The Harris family has farmed White Oak Pastures since the end of the Civil War. White Oak Pastures is also a Savory Hub and I am fortunate to consider Will Harris a colleague and a friend. Will graduated from Georgia with an Animal Science degree and followed all the best practices that he had learned at Athens. However, 25 years ago, he went through a Model Crisis and underwent a paradigm shift and started to farm with a regenerative lens. This is the model that he drew for me at dinner in March to demonstrate the space that White Oak Pastures works in – the intersection of animal welfare, land stewardship and community. Every day, they butcher meat from animals raised in a regenerative manner using humane animal management practices. The following slides are a good example of how he does all three.

White Oaks Pastures is the largest supplier of animal protein to Whole Foods in the Southeast. They raise and slaughter 10 species of livestock and are the largest free-range poultry producer in the United States with over 100,000 on pasture on any given day. Will keeps on pushing for a closed loop system with zero waste. Anything not used from the slaughterhouse is composted and the resulting compost put back on the land. They also believe in value added and Will is always searching to improve his stewardship of the land, his family's farm and the community.

Will continues to acquire land that is contiguous to his existing holdings. This picture is of a peanut field that he acquired in 2016. This field had less than 1% organic matter and such a heavy herbicide residue it was hard to establish an annual rye grass cover crop. The next step would be to free range chickens on the field. Each slide is a different field in a successive phase of regeneration. In addition to chickens he will also use hogs, especially on the field edges bordering the woods. The "edge" is where species diversity exists and what has largely disappeared from agricultural lands in the United States. I remember when I was young, hunting pheasants along the edge of fields in California. However, by the time I was in high school those edges were gone as were the pheasants. Will's ultimate holistic context is to establish a savanna consisting of open woodlands and perennial grasslands. Then he brings in his cow herd as well as compost and other organic material. And after 7 years the land has regenerated into highly productive pastureland that he uses to grass finish his cattle for market. Through these regenerative practices he has regenerated the ecosystem processes resulting in healthy soils with active soil biology and high forage productivity.

The Brown Ranch in Bismarck, North Dakota is another example of a holistically managed, regenerative farm that is an integrated cropping-livestock system. Gabe Brown has increased their soil OM to 8% over the past 25 years by focusing on improving soil health on their 5000 acres. A typical rotation would be the following: Winter Triticale/Hairy Vetch crop; followed with a warm season cocktail cover crop of 12 or more species; then grazed any time between October and January using Holistic Planned Grazing. Brown practices zero-tilling and keeps the ground covered 100% of the time. He also has eliminated synthetic fertilizers, pesticides, and does not use GMOs.

When you have functioning ecosystem processes you increase the resilience of the land. This picture of a field at the Brown Ranch is an example of that resilience. This image of a thriving cover crop was taken on August 20, 2013 with a temperature of 104 degrees F. The cocktail cover crop of 12 different species was planted June 26, 2013 and had received just 38/100" of rain since June 12, 2013. That works out to 123,832 gallons per acre. This field has 8% soil organic matter. Each 1% increase in organic matter holds 16,500 gallons of water per acre per foot (Scott, Wood & Miley, 1986).

Consequently, this field was able to retain almost all that water making this cover crop possible. Brown Ranch increases their economic diversity by stacking their enterprises. With minimal inputs the Brown Ranch consistently beats the county averages for both corn and soybeans. They do not concentrate on maximizing yield per unit of land but rather maximizing profit per unit of land.

Regenerative agriculturalists like Will Harris and Gabe Brown have had a paradigm shift– they are focused on food and fiber systems that regenerate the water cycle, mineral cycle, energy flow and community dynamics while at the same time being economically and socially sustainable. It is also important to point out that both Will and Gabe are doing this at scale – these are highly productive, profitable farming systems that have not only regenerated their land but also their communities. There are increasing numbers of producers across the globe that are undergoing this change in paradigms. I have been on scores of farms and ranches across the United States as well as Cuba, South Africa, Malawi, Kenya and Zimbabwe that are practicing regenerative agriculture. What we are working on at Michigan State is to normalize Regenerative Agriculture through interdisciplinary research with intentions to become transdisciplinary and close Kuhn's cycle.

As stated earlier linear science is not well suited for addressing wicked problems due to the need for interdisciplinary approaches as well as taking into consideration the social component of them. Almost any RFP from USDA or NSF emphasizes interdisciplinary or transdisciplinary research. AFNRE researchers are uniquely positioned to be integral members of these teams. In order to do so we must continue to broaden our toolboxes.

When I was in my doctoral program in the late 1980s, I was very single minded in becoming a quantitative researcher. I sought out every course I could take on quantitative methods and my vision of the perfect study was one that employed a true experimental design. I now realize that reductionist methodologies are ill suited for studying the grand challenges facing the complex systems that we, as researchers intersect with. Consequently, we need to utilize a mixed methods approach as well as rely on additional methods from other disciplines. I would argue that many of the researchable areas that AFNRE focuses on would benefit from Participatory research where the community is not being researched but rather a participant in the study with the goal of applying the results to help solve or mitigate the problem. Participatory research falls along spectrum from the extreme end where the community dictates the research questions and methods to the other end where the researchers help formulate the questions while designing the methods and data analysis. Subsequently the researchers assist the community with using the results. Other related methods include the use of modeling and network analysis. Modeling long used by the natural sciences is now a commonly used methodology in the social sciences. Network Analysis is a type of modeling that has specific attributes that makes it a very appropriate modeling methodology that should be employed by AFNRE researchers.

The United States Department of Agriculture (USDA) National Institute for Food and Agriculture (NIFA) Agriculture and Food Research Initiative (AFRI), USDA Sustainable Agriculture Research and Education (SARE) and National Science Foundation (NSF) CNH2: Dynamics of Integrated Socio-Environmental Systems are three funding opportunities that have NOT traditionally been led by AFNRE researchers. However, by leveraging our broad understanding of food and agriculture systems coupled with our social science and educational backgrounds we can position ourselves as Principal Investigators on these types of proposals.

The establishment of an entrepreneurial local nutrient dense food production incubator in Michigan's Upper Peninsula (UP) was developed by an interdisciplinary team, led by me as the PI, with the goal of increasing the number of farmers in the UP growing nutrient dense food. Michigan's UP is a food desert and typically lags economically behind the rest of Michigan and the US. This project established an incubator for new farmers as well as conducting research and teaching on growing nutrient dense food north of the 47th parallel. The project took the original Experiment Station and re-tasked it as a teaching and learning farm specializing in nutrient dense food production. I am a faculty coordinator for the Upper Peninsula Research and Extension Center which encompasses the North Farm. This has helped provide us the infrastructure needed to research and teach Michiganders about regenerative agriculture. The USDA NIFA AFRI grant was the first brick in the foundation of this program. Being located at the 47th parallel makes for long summer days and colder winter days. However, in 2018-2019 with165 inches of snow we were still able to market fresh vegetables 12 months out of the year through a combination of hoophouses and root cellars with minimal energy costs.

Our interdisciplinary team has been able to secure three consecutive North Central SARE grants – each with an AFNRE researcher as the PI or co-PI. The first one trained 17 producers on how to grass finish beef resulting in 600 head being placed into Northern Michigan markets. The project included developing and conducting grazing workshops for producers as well as workshops for chefs and suppliers. Focus groups were conducted with all participants as part of the evaluation program. The strength of this project was the interdisciplinary approach that was taken by the principal investigators. The current SARE project is in the UP, which includes Aaron McKim and me as Co-PIs. We created 7 teams across the UP consisting of a classroom teacher, their class, a producer and Extension educator to identify a problem facing the producer and for the class to research and implement a sustainable practice to address the problem.

The last example is an NSF proposal currently under consideration and also led by an AFNRE researcher at MSU, Dr. Jenny Hodbod. This is a $1.6 million project that proposes to study the environmental and sociological dynamics of grazers in Kenya. We have two AFNRE researchers, and ones from geography, tourism, animal science, fisheries & wildlife, water science and resource economics.

A growing amount of evidence is indicating that it is the how and not the cow. We have done Life Cycle Assessments at Lake City Research Center and White Oak Pastures on grassfed beef. These LCAs are based on actual, on the ground data and not on computer models like so many LCAs are in the literature. At Lake City we have found that we have more than offset emissions from our grassfed cattle through sequestering carbon in our pastures (Stanley, Rowntree, Beede, DeLonge & Hamm, 2018). Concurrently, we have increased the Animal Days per Acre by 25% - this is like getting free land. At White Oaks Pasture the LCA found that cattle were carbon neutral and the farm as whole 85% carbon neutral (Thorbecke & Dettling, 2018). We are proving that agriculture can be a solution rather than a contributor when it comes to greenhouse gas emissions.

What You Do Is What You Learn – WYDIWYL, a phrase coined by Andy Anderson at MSU, best frames the way I learn and what we emphasize to our pre-service teachers at MSU. Regenerative agriculture also implications for teaching. We must remember our roots and that AFNRE traditionally approached teaching from an interdisciplinary approach. When I first started teaching, we still taught courses such as Ag I, Ag II, Ag III and Ag IV that were more focused on systems rather than disciplines. There was also a heavy reliance on the Problem Solving Approach and experiential learning. Do we truly follow our roots? I feel that we shifted to a reductionist approach in the 1980s as a matter of survival, when we placed our curriculum into disciplinary silos - Animal Science, Plant Science and so on. I was one of the early adopters of this in order to obtain science credit for my courses in order to maintain enrollment. However, now I argue we need to take the best of both. Creating a foundation of content knowledge through STEM education but taught in a holistic manner with an emphasis on addressing the grand challenges facing agriculture and food systems.

My best learning has always been in the field. Iowa State's 450 Farm is a prime example of the type of learning when students learn by doing. My animal science colleague, Dr. Jason Rowntree and

I are working on a field school model (Figure 1) for the preparation of holistic educators that is predicated on learning about agriculture and food systems around the ecosystems processes with the goal of teaching a generation of regenerative agriculturists.

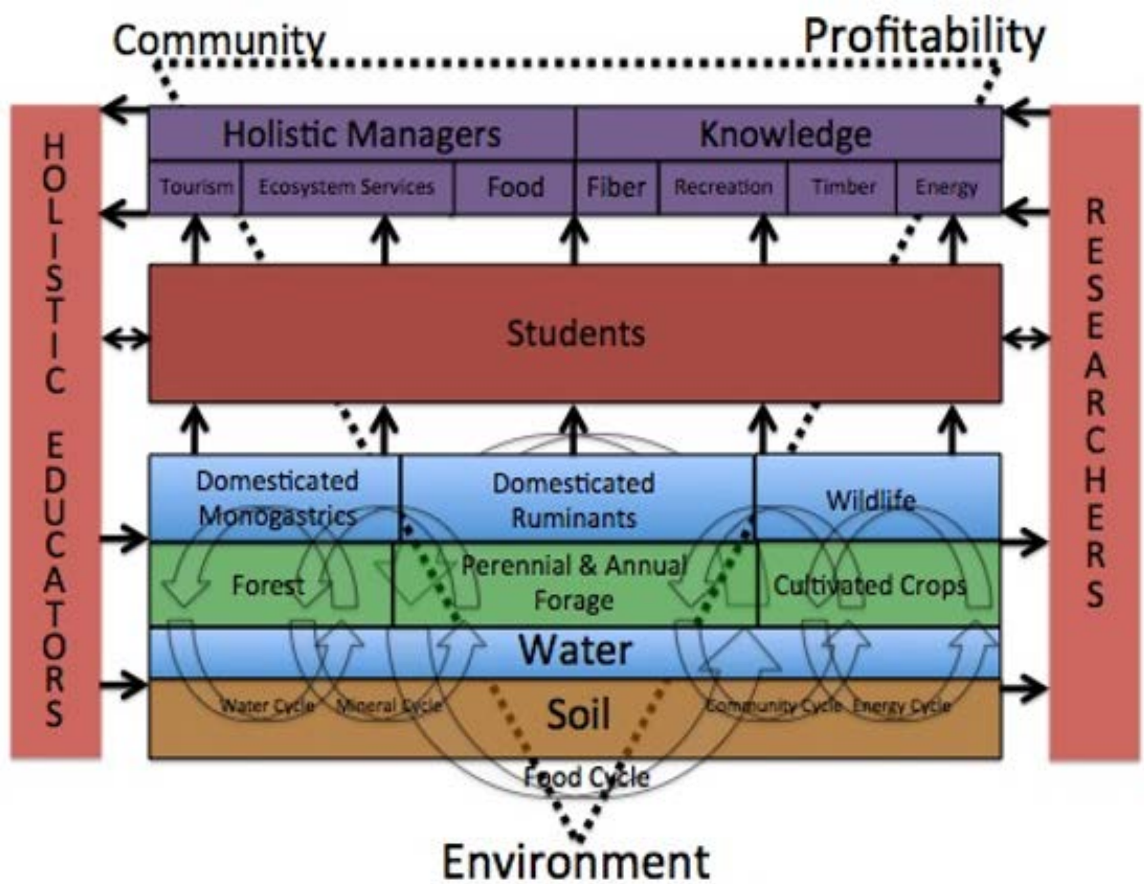

Figure 1. Field School Model.

The last book on my list of books is also the most recent one written by Charles Massy of Australia - *Call of the Reed Warbler*. Dr. Massy takes an in-depth look at several regenerative farms in Australia and the progress they have made in regenerating their land. Massy considers agriculture up until WWII as the organic mind and the agriculture after it as the mechanical mind. He builds the case for a new era, the emergent mind, where regenerative agriculturists work with nature rather than against it. Doniga Markgard, a regenerative rancher in the California Bay Area, contends that we need to "tend the wild not tame the wild".

I truly believe that AFNRE is well positioned to provide educational programming, both formal and non-formal, to teach students how to become emergent thinkers. AFNRE researchers are also uniquely well suited to be connectors in the interdisciplinary research needed to develop and test the efficacy of these emergent food and fiber systems. Notice that I have not used the term "industry" once throughout this talk. I would contend that you cannot industrialize a natural or soft system without unintended consequences. I know that my paradigm has changed. I drive down the road and I am constantly reading the land. No rancher or farmer degrades their land on purpose - it is the unintended consequence of us trying to industrialize a complex system. I know this view challenges the values and core assumptions of many of you in the audience. This is one outcome of a scientific revolution. The other is a normalization of the paradigm change to normal science and the cycle starts again. I also know that it is how I am going to finish my career, researching and teaching the best way to achieve the golden ticket of producing food and fiber while regenerating the land and communities. Thank you.

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