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Sustainability and Resilience at The Happy Berry: Climate mitigation and adaptation action plan[1]

It is plain that global warming is happening and is being driven by the use of fossil fuels and how we do agriculture. In 2016 seventy plus percent of us know we must transition away from fossil fuels but only a few of us grasp that the 12,000 year old (paradigm) way we do agriculture, must change! Agriculture worldwide is responsible for thirty plus percent of global warming gases. The purpose of this action plan essay is to focus on how "The Happy Berry" can become:

1. A sink instead of a generator of global warming gases,
2. Survive droughts (more frequent and greater intensity) with less water due to greater evaporation associated with higher temperatures,
3. Floods (greater winter precipitation)and the associated opportunity to recharge ground water,
4. More violent thunder storms and tornados in both summer and winter associated with slowing and wobbling of Jet Stream,
5. Higher and more erratic temperatures (thus more heat stress on plants, animals, workers and clients),
6. Fewer days with freezing temperatures (less chill units), while same time suffering more extreme freeze events

[1] Walker Miller, the author is a retired professor (99) of Plant pathology and physiology, Clemson University, A Land Grant (1864) university in Clemson SC. Currently he is a fulltime subsistence farmer farming approximately 22 acres…perhaps his 401 K.

7. Shifting ecological habitats (for example favoring vectors of diseases of plants, animals and humans),
8. Duration of seasons (currently 8-9 days longer and projected to be 14 days with in 5 years).
9. Environmental refugee's influx…internally displaced persons to be politically correct.

After reviewing climate impacts for other regions of the North American Continent and the rest of the world, because of water potential of the southeastern USA, if managed right with a new agricultural paradigm of perennial commodities, the southeastern Piedmont could become a major agricultural producer. With industrial agriculture it is envisioned that perennial commodity production would not satisfy need for local food economies and in fact would be in competition with local economies necessitating policy changes like perhaps export tariffs to protect both local resources (water for example) and economies.

The proposal of tariffs presents us with the problem of "Life boat ethics." There is a limited carrying capacity of the bio-region or planet earth for that matter which immediately invokes the "tragedy of the commons." If you exceed the carrying capacity of the commons the commons is destroyed and all is lost. The life boat ethic says that leaders must prevent the tragedy. Then there is the battlefield triage where you divide those wishing to enter the commons into three groups, those who won't make it, those that might make it and those who with help will make it. The solution to the tragedy of the commons is bio-feedback. Policies that provide bio-feedback for bio-regions must be initiated now coupled with policies that discourage

colonization of local economies and communities that we know will be disturbed to the point of creating climate refugees.

Given the above…How does The Happy Berry envision it will fit into our future low energy community and bio-regional economy of the upper Piedmont eco-region of South Carolina USA? A national survey of communities indicated that 59% acknowledged that they needed to plan for climate impacts but only13% indicated they were developing a local risk assessment. I would hazard a guess based on conversations locally and with groups like the Farm Bureau that there are no assessments addressing the issue of climate change on local food. The subject of "Food Hubs" has become a local buzz word. The ideal food hub is a cooperative that provides accumulation and distribution services. A food hub fits the resiliency model of modularity but it is the first step in removing bio-feedback. The Food Hub, as currently being promoted locally and I believe nationally, is an adjunct to the industrial food system and not focused on local co-mensal communities. Farmers markets, a few independent grocers, on-farm marketing, Community supported farms and pick-your-own are providing direct feedback not provided by local sales to Wal-Mart.

As a business family (and a small farm) it is our job to assess our environment and business model to position ourselves for the future. The land and the environment in the very broadest sense of the word is our investment for the future. The objective is to sustain our family, community and planet. To do this we must assess the history of the land and use the lessons "of place" as well knowledge garnered as conscious beings to guide our investment in place. Mother earth using the resources "of place" through redundancy and resiliency maximizes production but not necessarily efficiency with the capability to

withstand disturbance in an evolving and changing world. To this end I will review the carbon cycle as it relates to farming, the history of the land and major plant growth nutrients of the eco-region.

Man, as a species, has failed to limit global warming and must now suffer the consequences of climate change for next 50 years or more. Our objective is survival of man. To do this each of us must mitigate and adapt to our new climate. Normally climate change is slow (thousands, hundreds of thousands to millions of years) and through redundancy, resilience and selection mother earth has maintained maximum production of place. This time the change is so rapid we could/will see eco-regions collapse. Perhaps as conscious species we can help mother earth adapt by moving plants/life forms that are adapted to the new climate or configure cultural systems resilient to new disturbances.

I/we will address what we perceive as threats of climate change to our 22 acres and how or how we hope to address them. These threats include loss of yield, fertility, organic matter, moisture, forage associated species and increases in wind damage, heat damage, soil erosion, spring frost damage and variability of season length, chilling and heat units to name what comes to mind.

The Carbon Cycle

Mother earth is living being made up of non living chemicals and living plants, animals (including humans), bacteria, fungi, viruses, nematodes, worms and others. The living portion of mother earth uses carbon to fix energy from the sun in configured carbon compounds, fixing carbon, and then uses that carbon as stored energy through the process of respiration to create more life forms and releasing carbon dioxide.

Most carbon is fixed through the photosynthetic process where carbon dioxide and water in the presence of a molecule chlorophyll which has captured energy from the sun to sugars. The sugars are transported around the plant to do the work of growth and capturing minerals from the soil necessary to do that work. In the roots the sugars are made into chemicals that are released into the soil to carry out a multitude of functions like protect the plant from other invading plants. Sugars are pushed into the soil solution feeding a myriad bacterial, fungal and numerous animals. The waste of one life form is food for another. The carbon cascades though millions of organisms to form a final waste product call humus. Humic materials, depending on source (some are more recalcitrant), are resistant to oxidation especially in oxygen starved/limited environments due to slowed diffusion of air at lower soil depths. These humic materials form organo-mineral complexes that have charged ends which enable the soil to hold onto other minerals and cement minerals together to form soil aggregates. These soil aggregates can be thought of as homes for the soil bacterial and others to live. The aggregates can bind together to form larger aggregates that can act like communities. The aggregates absorb and adsorb water kind of like the plumbing in the house and community. The fungi in the soil can be thought of as "super highways." Many of these fungi lack cross-walls or have porous cross-walls that transport difficult to obtain minerals like phosphorus over long distances to the roots. The result is a healthy soil that can have organic matter levels that can range from 2 to 12 percent or more.

If you plow the soil you destroy these "super highways" and expose the humus in the aggregates to oxygen so that it is burned up.

Much has been made of no-till agriculture (not plowing) arguing that leaving the organic matter on the surface increases soil organic matter. The truth is these gains in organic matter are short lived. Residue on the soil surface is rapidly degraded because of its' exposure to oxygen. The roots of plants in annual agriculture systems are shallow and ephemeral. Residues and roots can be classed recalcitrant or as readily degraded. Annuals, for the most part, are in the class of readily degraded or oxidized easily.

To improve organic (carbon) levels in the soil the real key is to include perennials into the mix, especially if those perennials are recalcitrant and increase carbon fixation at greater depths above and below ground level. The annuals are important for fixing carbon that will be readily degradable carbon to feed the bacteria which will result in even greater amounts of humus formed from the more recalcitrant carbon materials of the perennials.

Fires are an important part of the carbon cycle. Fires, that burn under oxygen limiting conditions, form biochar (charcoal). Biochar is recalcitrant and especially where mixed with residues that provide sugars and nutrients form very stable humus.

Bottom line of this "thumb nail" of the carbon cycle…most of the carbon in the world is stored in the soils of the world…more than in fossil fuels or in the air. Man has been exploiting this carbon pool for 12,000 years. It is time that agriculture becomes a sink instead of a generator.

Adaptive and mitigation action plans associated with carbon sequestration -

We have planted Loblolly, Longleaf and Italian stone pine in east west rows across the farm right into the blueberries, blackberries, figs, muscadines, goji berries and Izu persimmons. And will expand to other crops if what we are trying works. The loblolly sequester carbon for 100 years, Italian Stone Pine 250 and Longleaf for 500 years.

The objective is to have multi canopied fixation of carbon with complimentary recalcitrant and non-recalcitrant carbon.[2] The risk is that we do not know when each of these crops reach photosynthetic saturation. Many commodity crops reach saturation at about 30 to 40 percent full sunlight. If we knew the answer we could bioengineer the system better. There is no information except slivipasture that suggest density of trees and we have not found any information with regards sunlight saturation associated with that information. The local land grant does not seem to have any assistance in this area.

We are spacing the east west rows about 75 to 100 feet apart and in row about 20 to 30 feet apart. Crop rows are mostly north south as we can make them given terrain to facilitate maximum sun exposure without exposure to soil erosion losses. To date the loblolly have grown the quickest as well had the best survival. Some are as much 20 feet high in 2016 after just 3 years. The plan is to limb them up as they grow. Pines were selected because they are non epicormic meaning they do not put out additional branches when you cut one off.

We have left east west alleyways so while we go through the transition from small trees to large trees so that the wind machine for frost protection will still be functional. The plan is to remove the bottom

[2] New Phytologist (2014) 203:1-3 and 110-124

branches each year maintaining two thirds of the photosynthesizing canopy till we are about 40 feet above ground level. At that point the wind machine will be able to push wind under the trees for frost protection while at the same time the canopy will reflect heat back to the crop plants for passive frost protection.

In addition to carbon sequestration the objective is summer cooling to combat heat stress and damage to plants, fruit, and harvesters as result of climate change. Who amongst us has not walked underneath the canopy of tree on a hot summer day and thought, whoa! It must be 10 degrees cooler here. There is, "a lot between the cup and the lip" (to learn) with this observation. Please see the side bar - "Lessons learned from Shade cloth deployment"

Side Bar – Lessons learned from Shade deployment

Recent blackberry breeding efforts by Dr. John Clark of the University of Arkansas have resulted in the development of primocane bearing blackberries. Observations in regions blessed with cooler summer temperatures indicate high production of excellent quality fruit. We thought…Simple we will just put up shade cloth and cool the flowers and we will have the same results in our area which has hot summers and due to get hotter with global warming and climate change. We wrote a grant proposal and submitted it southern SARE (Sustainable Agriculture Research and Extension). This is a USDA regional project to foster site specific grower research. We were funded for two years in 2014! It required an approximately 50 percent grower match in materials and labor.

After two years of observation what did we learn? Air has lower heat holding capacity thus it warms very quickly after sunrise and cools

rapidly after sunset. Plant tissues have much higher heat holding capacity because they are mostly water which is much denser than air. The physical principle involved is that heat energy always moves from the hot to cool. So as the day progresses plant tissues absorb heat both from energy wave lengths from the sun and ambient air until the tissues equal or are greater than the air temperature when heat from the tissues move to the surrounding air. This process is impacted by air movement both when the plant tissues are cooler or hotter. When plant tissues are hotter wind takes heat away. Therefore when shade cloth reduces wind run it reduces heat removal from plant tissues. Therefore the shade cloth for the first part of the day reduces the rate of heat gain by plant tissues through solar radiation but eventually it reaches the ambient air temperature as heat from the air flows toward the plant tissues and then because of lack of wind run go higher than ambient temperatures. The white drupelet problem was reduced in blackberry but processes like flower initiation, development, pollen viability and success in fertilization and white drupelet formation may vary in sensitivity to heat stress. It takes 50 days plus or minus to go from flower to harvestable fruit. So flowers formed within 50 days of first frost will be killed. Therefore only flowers formed that successfully went through the process above prior to very early September will be successful. Bottom line shade cloth delays but does not stop plant tissues from reaching high temperatures in the southeast with number of days above 95 degrees increasing from 10-15 to 30- 35. This means that yields experienced in cooler regions will not happen in the hot southeast. For more detailed discussion the reader referred to SARE report at our web site (www.thehappyberry.com).

Plants carry on evapo-transpiration and shade cloth does not. Evapo-transpiration is the cooling system of the plant. As a molecule of water moves from the liquid stage to the gas stage, transpires in a plant, it absorbs the heat from its surroundings. Convection and wind move the energy away from the plant stabilizing the plant canopy at cooler temperatures. The air temperature beneath that canopy has been documented as being as much as 10 to 30 degrees cooler depending upon thickness of canopy and species which differ in shape, angle and number of leaves.

A secondary canopy beneath the top layer of would not only receive reduced amount of energy from the sun to be absorbed by the plant but as a plant in a cooler air environment below a primary canopy it would stabilize at a lower temperature. Will it be enough to enable primocane blackberry development in the southeast? Only time will tell. This is a long term experiment with no support or help from land grant professionals. It is our wish that the Land Grant System or perhaps private sources of money…we have thought about "crowd funding"… could help. Extra dollars are just not available given the smallness of our farm and the need to provide a living wage for those who participate in the farm.

End side bar

We covered 1000 feet of row with a trellis of our own design which was one tenth the cost of what was commercially available. It lacked all "the whistle and bells" (automation features) of commercially available. To make a long story short we learned some basic principles of physics and was a demonstration that negative results are valuable.

Italian stone pine, if successful (we know of at least one other tree growing in the area), will provide edible pine nuts and also has what appears to be a natural canopy ideal for multilayered canopy production. Long leaf is very slow to establish but we could not resist the opportunity to go for 500 year of carbon sequestration. When it comes to carbon dioxide sequestration there is point as the tree gets older that carbon fixed to carbon released back to air ratio goes from positive when young to equal at maturity and finally negative in old age. This principle of carbon fixation is unique to the species. So the long term plan will require tree removal and replacement. There is much to be learned in this area that a Land Grant University could help with, research plots that would go 100 to 500 years or if we used redwood (Sequoia sempervirens) 1800 years! This kind of research could only be done through public supported institutions like bio-regional Land Grant universities.

University (Land grants) have been very quiet, doubtful and quick to point out what they perceive as problems. We do not see any effort to consider a change in the current paradigm of fruit production.

Agriculture History of The Happy Berry

During the last ice age humans migrated from northern European Plain to North America down the east coast. They lived as hunter gathers and were not farmers. Most refer to them as the “wood land people.” They used fire. Between lightning and purposely set fire large portions of the eastern piedmont were maintained as a grassland savannah. The grassland was made up of several different species of perennial grasses as well as legumes with swards that were 12 to 15 feet tall with root systems that could be as much 10 to 12 feet deep. When these grasses

burned they created biochar out of the stems that were close to the ground because the fire above consumed the oxygen. The combination of recalcitrant roots, limited oxygen in the soil profile, biochar, legumes and moisture created deep fertile soils despite the fact that piedmont soils are very old, consisting of weathered clay with very low cation exchange capacity.

The river valley below The Happy Berry was named for the mulberry trees that grew along the river. Keowee in Cherokee means Mulberry. Nearby mountains were populated with chestnuts a keystone species for the area and oaks.

The Cherokee arrived from the west about 1800 years ago. They anillated the woodland people. They were farmers but continued burning the savannah. With arrival of the white and black man with the technology to maintain animals without fences cattle was the next crop. During this period and transitioning to the next period subsistence farming was initiated using the plow. Then from around 1830 till 1930 the combination of cotton and the plow resulted in complete erosion of the fertile savannah leaving a highly degraded soil. The degraded land has persisted till today despite the valiant efforts of the Soil Conservation Service (Now known as Natural Resource Conservation Service NRCS) and the invasion of trees.

The Happy Berry is located on the east side of an 18,000 acre man-made reservoir in United States Department of Agriculture (USDA) growth zone 8A (minus 10 to 15 degrees Fahrenheit). The sight was selected because many fruit crops are frost sensitive. Satellite recognizance showed the site, which was selected because frost

sensitive Kudzu was still alive after freezes in the fall, to be 9 degrees warmer than ¼ of a mile away.

Adaptive and mitigation action plans determined/suggested from history – the lessons of place are perennialization, the use of biochar, importance of erosion control/management (discussed below under Water adaptation…) and site selection. We grow perennials at the Happy Berry as an adaptive strategy to sequester carbon and enhance soil fertility with greater water holding capacity thus capable sustaining crops through summer droughts and greater oxidation rate of carbon associated with higher temperatures. Part of this adaptation strategy Is learning the importance/difference in recalcitrant carbon and readily degradable carbon.

The plans are to build an on-farm biochar kiln. The proposal to date is also on this web site. The farm generates 5 acres plus of blueberry pruning stems that are too big to go through a side delivery mulching mower used to maintain the grass middles in the summer and grind the pruning's in the winter. These stems historically have just been hauled to the woods where they slowly decomposed. The biochar would be recalcitrant carbon. Poultry litter is available on-farm and is not being used well at this time. The proposal is to compost the two and then spread it in the field annually as part of the farm cycle. Increase humus will contribute recycling nutrients and reduced leaching loss from increased winter rains. This is a case of the blind leading the blind since our Land Grants universities, at least in our bioregion, are not doing supportive research. We are very worried about the impact calcium and other minerals in the biochar and its' potential impact on pH of blueberry soils.

Site selection discussed above enables use of the wind machine and the use of the inversion to combat polar vortex excursions of plant damaging freezes and bloom/fruit damaging frost events expected with climate change. In the past one to three nights a year has been typical with perhaps a slight trend towards increasing frequency. We anticipate more frequent use with global warming.

We have added mulberries as a production module to the farm. It represents a low frost risk crop because flowers and fruit are borne on current season wood that can be planted in the bottoms where frost risk is higher. Risks associated with mulberries are spotted wing drosophila as fruit harvested will coincide with peak SWD populations (see invasive species below) and deer foraging.

We are planning on adding chestnuts on steep hill sides and edges of terraces as a carbohydrate source for our community. High late fall and winter rains associated with global warming and our rugged terrain suggest annual grains are not a viable option for carbohydrates in our area/bioregion because of erosion. No work is on-going with regards to perennialization of commodity crops at the local Land Grant despite personal visits to promote it. The vision is that we would plant perhaps tea (we have a small test/learning planting), or filberts (hazel nuts) or both as understory crops. Filberts, 56% oil nut, could provide an on-farm fuel source as well as an edible crop. One daughter has studied on-farm making of oil fuels. Perhaps in a low energy economy tea would provide a locally available stimulant. We are also evaluating olives (Ascolana and Arbequina [others died]) which are theoretically possible in our growth zone with warming being a positive event for Olives. Plans are to install test planting of Golden Kiwi (sunshine + males) in frost free sites on the farm.

Invasive Species

July 1944 a large number of countries (44 with 730 delegates) met in Breton Woods Maine to develop the Breton-Woods Accords. The intent was to set up an economic system that would avoid the mistakes of the First World War that lead to the Second World War. Since it was the United State that was defeating Germany with their infusion money, equipment and soldiers the participants thought they would get "the short end of stick." They expected they would be exploited. Two economists John Maynard Keynes and Harry White proposed an economic monetary system that that would enable trade between countries despite their debts after World War II and also the US guaranteed that they would provide security for all member countries on the high seas. Many have joined the accords since the final signing in 1946. Keynes was an "economic growth" economist.

These Accords and the security of high seas trade by the US are the behind the scenes driver of economic growth for the last 70 plus years. The good news is that we have not had another world war (there was a cold war and posturing by non members of the Accords) but the bad news it has provided a conduit for pests, Invasive species, which has been devastating to US agriculture and elsewhere in the world… And economic growth which has been the driver behind the global warming gas emissions. There have been many twists and turns in the last 71 years with lots of countries added to the Accords but the bottom line is that "Keynesian" economics and international security on the high seas, the cheapest way ship goods and commodities, and the associated industrialization are the major cause of the of our current global warming, climate change and invasive species crisis. Both state and federal government (Animal and Plant Health Inspection Service

[APHIS]) have made a valiant effort, with some successes, but the budgets have been and are woefully inadequate to prevent introduction and spread of pests associated with the trillions of dollars of monthly trade.

The Happy Berry's recent invasive species includes Spotted Wing Drosophila (SWD), Brown Marmorated Stink bug, Kudzu Stink Bug, west Nile virus, Japanese bittersweet, wild pigs, and several blackberry viruses. “On deck” (therefore present in North America but not yet on farm) are the fig fly, Asian fruit fly, multi-flora rose, Spotted lantern fly, Chikungunya virus, New Guinea flat worm, avian influenza and threatening with global warming are zika virus, dengue and yellow fever, *Parthenium hysterophorus,* a weed that supports mosquitoes that spread malaria. As we walk around the farm approximately 50% of the vegetation is invasive species accumulated over the last 400 years.

All together of the 600 major pests that threaten agriculture today, 480 of them are invasive species.

I have attended several conferences addressing the climate crisis but the issue of invasive species is not seen as an issue with regards to the climate crisis. Bottom line… the farmer must mitigate, adapt or suffer the losses associated with invasive species.

Invasive species adaption and mitigation plan - when an invasive species is first detected (where possible we use baits and traps to detect them) the second step is to determine just how significant is the damage. For example, the kudzu stink bug although it was observed on grapes and various legumes used around the farm, the impact on the economic bottom line was minimal. The Kudzu stink bug actually helped reduce the invasiveness of kudzu (another purposely introduced

invasive species)for awhile. Kudzu management is still a problem though.

The Third step is to devise a management plan. We are plant pharmaceutical use adverse. For example, the spotted wing drosophila (SWD) was determined to be very significant ("game changer") therefore significantly reduced crop due to direct damage to blueberries, blackberries, significantly increase grading time for pre-picked berries and if we followed university control suggestions would significantly add spray costs. We attempted modifying our bait and kill strategy, which works extremely well, for the blueberry maggot, a native pest, and when explained to clientele is readily accepted, to include SWD. GF-120(Dow Chemical) a molasses bait with spinosad in it as the killing agent was spiked with blackberry wine and Monterrey insect bait and applied during blueberry maggot season and continued through the blueberry harvest season. Bottom line it collapsed in warm days of July and August so that by the 5 th year we had to use university recommendations and close the farm for one a day a week to meet pre-harvest intervals. We continue to work with USDA researchers on bait and kill based on visual stimuli as well as sugar (molasses) feeding stimulus but it also collapsed in late season blackberries. It seems that the problem is declining, Not as many sprays in 2016. The reason unknown. Perhaps earwigs and other predatory fauna under the bush(???).

We use modularity in the form of 6 or more perennial crops to improve farm resilience. We have observed that fruit crops with a relatively thick skin like seedless grapes and muscadines have not had a problem with SWD. We are now evaluating our varieties while grading to determine we can find tough skinned varieties as a mitigation strategy.

As an adaptive strategy we are evaluating seedless muscadine (Razzmatazz) as fall crop. Similarly we are evaluating golden kiwis which are also tolerant of SWD. Further, we would point out that pick-your-own is an adaptive strategy since clients pick only good looking berries and if promptly stored in the typical refrigerator the SWD worm is inhibited/killed.

We are dealing with a number of invasive species. We could discuss adaptation and mitigation for each but this document would soon become a book. The invasive species issue demands a lot management time in researching and learning sufficient information to execute a strategy and determine if it works. Another point is that a significant driver of global warming, consequently the invasive species issue is foreign policy (Breton Woods Accords) issue and as such requires a social aspect to adaption and mitigation of influencing government. Could policy change to tariffs on imported goods Favor localization instead of globalization?

Water Resources

Water availability was not adequately considered at The Happy Berry as city water was available and "cheap" at the time 1979. There are no aquifers in the region and wells are based on fissures which may or may not be productive. Average rainfall is 56 inches a year. Typically June, July and August have more rainfall than April, May, October and November but December January February and March are all over 5 Inches/month meaning good recharge of ground water. This is changing as noted above with dryer and hotter summers.

The Happy Berry is currently 90% irrigated using trickle irrigation. Currently city water is being used at $4.24 per thousand. What is not irrigated will be added.

The Happy Berry is in about 30 acre watershed. It has two small streams estimated at 3-5 gallons a minute. There are two wells, one at 1 gallon per minute and another at 4 gallons per minute. They were an $11,000 investment. In both cases what water that was found was between 80 to 100 feet. A plan to use solar and gravity for about 7200 feet of row is under development.

Given the geography, direction of rock layers, productivity of nearby wells a paid consultant advises no more deep wells and not to expect anything more than 1-4 gallons of more shallow wells (100 ft).

The upper part of the Keowee River Valley (now a reservoir) is transected by the Blue Ridge Escarpment. This geographic feature means that much higher rain falls, 100 plus inches per year at and above the escarpment, means a good recharge and through-put for the reservoir of approximately 700 million gallons per day. Clemson SC approximately 30 miles from the escarpment at the lower end of the valley gets 50 inches per year. A visit to the several river gorges through the escarpment which feed the valley shows that they ran at much higher levels within the last 500 plus years,

Water adaptation action plan – Install cisterns on The Happy Berry creeks. Use solar energy to pump water from both the cisterns and the wells to elevated locations on the farm and then gravity feed to trickle irrigation systems already in place. Add additional wells as we

can afford them. We sought assistance in engineering the systems from NRCS but other than a visit We could not afford their help. We will use sweat equity and cash as it is available to install the systems one at a time.

Use moisture monitoring at various levels and weather station data to drive the water usage plan, using ground water between bedrock and the soil surface as efficiently as possible. City water will be maintained as a backup to any local water management. We will continue to try to work with county government to enable use of the farm as tertiary treatment for water from local development sewage treatment systems. At least two developments are either in progress or a vision next to the farm.

Use swales as well as preserve terraces installed by the NRCS in the early 1900's and otherwise proactively recharge groundwater reserves that feed the fissures that our wells tap into and feed on-farm creeks. We will plant grass and perennial clover in parking areas using nutrient analysis and fertilizers to promote establishment during low traffic seasons. The risk associated with grass in parking areas, even though the parking area is gravel, is clients spin their wheels on dewy mornings. To mitigate the risk the parking is designed with bumpers and direction of travel so that they park parallel to the slope (perhaps 2%). Except for high erosion section of the driveways they are maintained as gravel to promote infiltration of water. We specifically will not pave the drive ways on the farm. The price is maintenance time.

The installation of trees as noted above under "carbon mitigation and adaptation action plan" will also increase deposition of water.

Although the trees will use groundwater for evapo-transpiration at the top level in the canopy personal observation indicates that lower levels of canopy have reduced evapo-transpiration. In fact in some areas of the farm the clay is slick, even though there is a grass cover, in shade grass is not as robust, and equipment has slid into and damaged trellis infrastructure.

Phosphorus

Phosphorous is in very low supply in the very old weathered kaolinitic soils left after 100 years of cotton in the Piedmont of the southeastern US and what is present is mostly tightly locked in the kaolin clay, generally unavailable. The tightly locked phosphorous can be extracted by fungi which require sugars pumped out of the root system by photo synthesizing plants. The normal cycle of phosphorus is for it to erode seaward attached to clay particles where it would absorb into the oceans food chain. Keystone species like the carrier pigeon (now extinct) and migratory fish swimming up river to spawn (no longer possible due to dams) would bring the phosphorous back to the Piedmont in an organic form to be moved about by land based food chain to be cycled back as humic organo minerals. This is a slow process with accumulation taking a long period of time to re-establish fertility.

To paraphrase a local saying by farmers: “phosphorous! Yes there is some 5 miles down the road at the feed and seed store.” In other words, today, it must be imported again and again…as soon as you apply it; it is locked into the kaolin clay which requires the slow process of extraction. To break out of the cycle, the organic fraction of the soil must be increased but our paradigm of annual plant production… of

plowing or even no tilling results in low organic soils which means low levels of available phosphorous for plant growth.

Similarly, the paradigm of annual cropping coupled with plowing and low organic soils necessitates the importation of other plant nutrients like potassium, calcium and magnesium. The objective should be to cycle nutrients annually.

Nutrient mitigation and adaptation strategies – the use of multiple canopy systems as discussed above is, we hope, to recycle phosphorous locally as well as increase organo-mineral humus. Controlling erosion slows the movement seaward but does not stop it. The loss of keystone species like the carrier pigeon and land based biota that cycled phosphorus from the sea means that some replacement will continue to be needed.

To facilitate on-site phosphorus management pre-emergent herbicides are not used and winter weeds, mostly annuals, are encouraged or supplemented with annual clovers (where pH is appropriate). Burn down products are used when evaporation is anticipated to exceed rainfall. The timing is critical because It is important the resulting mulch deteriorate sufficiently to release the nutrients in a timely manner.

This procedure also applies to potassium. Where we have been using annual clovers in the seedless grapes and muscadines we have seen a visible change in soil color…not much but some. Soil tests are expensive for carbon and are not used…knowledge of plant nutrient symptoms are used to decide when applications are appropriate unless they are not understood then soil tests are used. Also 35 years of experience are used in “cook book” fashion for annual nutrient

applications. It takes a really long time to build soil fertility so the occasional check when something is not understood suffices. A plan for use of biochar is in development and also available on this site,

Given the inherent vigor of a variety, amount of crop the plant is carrying, presence of absence of nitrogen fixing cover crops a myriad of other factors that only “footsteps in the field” can give you and ultimately the amount of growth is used for decisions on the amount of nitrogen applied in a given system/module. To paraphrase Wendell Berry[3] there is no substitute for the experience of multiple years of observation, over multiple crops, in the same location and what information has been garnered from a myriad of sources over time to make decisions for the next move.

The same, infrequent analysis can be said for nematode analysis. Perennial systems are notorious for building up plant pathogenic nematode problems (replant disease) over 10 to 50 years especially in monoculture systems. We have no experience that I am aware of in diversified multiple canopied systems. The Land Grant system nor private enterprise has come up with a nematocide system that works in perennial crops..

Marketing

Determining one’s environment requires that you study economics and decide where you fit in the economic system. That decision is based on what your costs are and what returns you need to make a living wage for your family.

[3] https://en.wikipedia.org/wiki/Wendell_Berry

Early in the history of the Happy Berry we started selling to chain/big box stores. They sorely wanted local food and suggested they could be relied on to pay adequately even after I told what we had to have to make a living wage. At time we were both employed off the farm. We were trying to grow the business so prices were not high. We made the investment in equipment, packaging, codes, stickers and insurance. Well it lasted about six weeks…we continued to hang on and changed chains. After two years we decided that we would stop…We were flowing money and not making what we needed. We focused on direct marketing and have not looked back. This next season (2017) will be 31 years.

Predicting the future is risky but from our reading we are convinced a growth economy is not sustainable. All the agriculture climate change impacts, although time lines differ, say agriculture as we know it today is going to collapse…salination of soil, sea level rise, exhausted soils, desertification, world supplies of nutrients given input-output (energy invested on energy invested; you can substitute any non-renewable nutrient) costs including direct and indirect, world fresh water supplies, temperature tolerance high and low, violent/damaging storms and more. Bottom line humanity must live a lower energy life! To us it is where we are at. We must mitigate, adapt or suffer the consequences.

Mitigation and adaptation marketing strategies – The adoption of direct marketing was/is our primary strategy. The adoption of a low energy, local and regional economy as a consequence of climate change is anticipated to be a "game changer" for direct marketing. A trip to "the farm" to purchase seasonal food will become much more difficult. The adoption of farmers markets is very important and strategies to enhance them are necessary part of our marketing plan.

We have installed bicycle rack at the farm. We have installed electric car charger at the farm with infrastructure to install more when need to.

Further it is important to support public transportation to provide access to the farm as well as farmer's markets. We plan on working with local churches, town halls and others that have unused parking for cars, to put up bike racks and waiting sheds and maybe bus docking stations and have room for buses to turn around without difficulty for public transportation. We also plan on working with the local public bus transportation to see if we can make it happen.

UDDT or urine diverting dry toilets offers the opportunity to reduce costs. Currently over $1120 is spent a year for portable toilets at the farm. Solar energy could be used to facilitate drying and odor management. The product of the toilet could be used in composting chicken manure and biochar before application at the farm. Providing toilet facilities is important to marketing on farm. This is adapting by using less water, less off-farm fuel, recycling nutrients on farm and increase living wage stream.

The transition to a local economy will be one fraught with problems. Although we take plastic money today we often say that we will also barter and take IOU's. Many times customers have been shocked when we do that. But the truth is we have never had a bad IOU over many years! Also we have received many a thank you note for doing so. We have even talked about issuing berry bucks! Could we develop a local currency that is not credit bound that would provide a medium of exchange when the collapse comes.

Energy

There is an energy input - output relationship with regards to quantity of food produced. That relationship covers direct and indirect energy. An economic system needs to free up some of the population of a community and bioregion so they can do those things necessary for a co-mensal relationship with our community, to have a civilization and culture. The base of that civilization is its' food production system and there must be feedback mechanism that maintains the balance with the rest of the local culture/civilization pyramid. Our current food system lacks that feedback mechanism hence population is either spiraling out of control or the population pyramid is distorted.

Our farm needs energy for us to support our community. That energy needs to support a tractor, produce cooling, water pumps for irrigation, customer transportation, lights, wind machine and small equipment, freezers and mower.

Mitigation and adaptation strategies for energy - Where ever possible passive means, like shade for frost protection and cooling will be used to reduce energy needs. Trees are currently being grown for this purpose and more are in the works (see above). We are planning to source of on-farm oil production for tractor and mower fuel as indicated above, both daughter Zoe and I have had limited training on this issue. We are planning on on-farm biochar production for electric generation using waste heat of the biochar kiln. Solar panels are planned for electric generation to run water pumps for gravity fed irrigation and back up freezers and cooler. Although we plan to stay connected to the grid for backup and storage it is hoped we can reduce purchased energy inputs.

Safety

Our bio-region Is characterized by steeply rolling hills, especially in the inner Piedmont where The Happy Berry is located. The presence of invasive species driven by climate change as explained earlier and a few native pest's means in order to mitigate these pests it is necessary to use plant pharmaceuticals… or abandon the crop being grown. The planting of a perennial crop is a 5 to 250 year investment. Invasive species have left their natural enemies behind, therefore defense is necessary.

The application of plant pharmaceuticals involves targeted spraying applying the right plant pharmaceutical, at the right time, in the right way with the right amount. Frequently this means applying during periods when it is unsafe because of weather or you literally cannot get in the field. Research takes time to come up with mitigation strategies. For example, The spotted wing drosophila has been on our farm for 5 years as of 2016, and the only viable strategy to date has been to use multiple different insecticides to avoid resistance development, applied at 5 to 7 day intervals multiple times and we have not been able to get into field to make those applications and observe the pre-harvest intervals and harvest the fruit when it is ready.

Adaptation strategy for safety – The use of drones for plant pharmaceutical application would be an excellent solution for the problem outlined. We are working with the Dr. Joe Mari Maja of Clemson University we hope to demonstrate to the FAA that this is an appropriate use of this technology. Unfortunately small farms are not perceived as important and funding has not been available to date.

We have rolled tractors on our land 5 times (no one hurt to date). The result is that we have been turned down for tractor insurance. The

cause of these accidents is the result of safety equipment that actually makes the equipment more dangerous in hill country and the failure of tractor companies to make 4 wheel brakes on small farm tractors that work on steep land. They are only adequate for flat land.

Climate Refugees

Seventy percent plus of our North American population lives in the littoral (coastal) zone, an area that will suffer the impacts of climate change. With decreasing water availability in these areas, increased salt water intrusion, rising sea levels and the threat of super storms we anticipate our communities will be faced with internally displaced persons. The first to leave will be the professionals who will try and salvage their assets. The next wave will be those that have lost assets of their homes or are greatly devalued. These folks will be desperate for shelter and food. It is possible that governments will be heavily stressed. This issue was addressed in the introduction.

The adaptation mitigation strategy to climate refugees – the answer is to participate in public discussions and address our politicians constantly for policies that either mitigate or provide adaptation mechanisms for these refugees. To this end we have been giving 10 or more talks a year on "The Future of Food." So the concept here is waste is being poured into our environment and it is damaging our planet. It makes no difference if it was intended damage or non intended damage. I like the analogy that grandpa left the water running in the tub and forgot it. It overflowed and soaked through the floor and damaged the ceiling and furniture in the apartment below. You are going have to pay for the repairs and furniture even though it was an accident/not intentional.

We and our parents and our grandparents and those who have gone before us have enjoyed lives where we burned/used cheap fuel and poured pollution into our environment from that cheap energy. We are responsible. We did not know nor did we intend to do this damage. This is not something that we can voluntarily fix individually. The purpose of government is to enable us do something as a group that we could not do individually. We need to form "Future Generation Climate Change Fund" (FGCCF) for the purpose of mitigating and adapting to climate change. The development of FGCCF should be done at the local, State and national level. Mitigation and adaption to climate change is something that must be done at all levels. At the local level it is something like this plan for our farm. At the national level it is compensating lesser developed countries for the damage that we and forefathers have done…similar to grandpa leaving the water run in the tub. And, of course, our state needs to be fostering adaptation and mitigation plans for our state littoral zones now, to reduce refugees later.

The big question is how do we pay for all this? The answer is we tax ourselves at the local, state and national level. The next big question is how we spend this money? The answer is we study how climate change is going to impact us locally, in our individual bio-regions, nationally and internationally. Then develop action plans…much like what is proposed here for our farm… then execute them. I must say that since only 70% believe that climate change is here there is need for an educational component to the plan at local, state, national and international levels.

The purpose of FGCC-fund brief proposal is that if we consider climate refugees a problem that we must act now socially and politically to

prevent or minimize the problem. "A onze prevention is worth a pound of cure." It is legally dubious, strategically foolish and ethically shameful for us to do otherwise. We would be committing these refugees to a sentence misery and possibly worse. Creating this fund is not a gift...It is not charity…It is compensation for the damages we and our forefathers have done in the past.

Discussion

There are two visions of the future of food. The first vision argues that the "future of farming is already here: the planet just needs to embrace it.[4] It argues greater intensification meaning higher/greater economic through-put of energy and other limited natural resources. This vision will entail a waste stream. The second vision is a low energy and natural resource through-put system with a waste stream that cascades through the carbon cycle mentioned above and stores our natural resources as organo-mineral complexes in the soil resulting in enhanced fertility and further reduction in the need for off farm inputs. It is the intent that the low through-put be capable of feeding lots of people in our community and/or bio-region. This is not to say that we will not use technology. Technology is and will be an important part of managing such things as invasive species until mother earth can resume or catch up on management. It is our hope that on-farm energy technology systems will significantly reduce the use of off-farm fossil fuel and or high waste stream energy. Technology is important in this action plan for our farm.

[4] Newsweek, 11.06.2015/Vol. 165/16 page 30-39 by Betsy Isaacson. Vegetable Growers News (VGN), November 2015. Field of the Future, pp cover and 6-7

I recently read Laura Lengnick's book "Resilient Agriculture: cultivating food systems for changing Climate[5]" and book by Mark Hertsgard "Hot: living through the next fifty years on earth.[6]" These two books along with many, many others I have read on… the evidence for climate change and what might happen if we do nothing, try to find a "silver bullet," delay to fix it later… are what prompted me to write this report for our Happy Berry Board of Directors. It is my greatest hope that "The Farm" (The Happy Berry) will carry on, hopefully for our family long into the future.

In some respects it is 100 to 500 year plan that will need revising again and again. It will forever be in draft form. Hopefully the objective will remain to be resilient and sustainable for our family and for the planet.

In order for the farm to support a living wage for family members it obviously must grow some with more family to support. This is not economic growth as perceived by the industrial food system or current capitalism. Currently income provided by the farm is not providing an adequate living wage for the family members. Off-farm income is being used at this point.

So what is resilience? Is it being able to recover after disturbance like a major freeze, drought, tornado or some other catastrophic event? Is it redundancy in function like having diverse crop modules, or having diverse market systems like farmers markets, on-farm direct marketing and pick-your-own? Actually, for this action plan it is all of the above.

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[5] Laura Lengnick, 2015 Resilient Agriculture: cultivating food systems for a changing climate. New Society Publishers pp357

[6] Mark Hertsgard, 2011 "Hot: living through the next fifty years on earth. Houghton Mifflin Harcourt Publishing, NY, NY

For this plan the farm has been divided into crop modules[7]… Blackberries, blueberries, seedless grapes, figs, muscadines, chickens, persimmons, pussy willows and other decorative woody florals and more is envision for the future such things as chestnuts, kiwi, tea, filberts that can complement the common core of the farm such as equipment (tractors, mowers, sprayers, market vehicles, tools, etc) sales center, labor, land and capital assets. The future is we could add, delete or substitute modules.

Too often dollars are considered the only important asset. There is the human asset (what you know), social asset [(friends and clients) a frequent comment you hear at The Happy Berry is 'that persons money is no good', meaning they are an asset], natural assets like the fertility we are building in the land, no matter what the crop, and physical assets like public transportation and land grant system of universities. Last on the list is actual money assets in a bank. It has always amazed me what you can do with work (sweat equity) that can increase all aforementioned assets without money assets. The objective should be to be debt free so you do not lose afore mentioned non-dollar assets which are more valuable in "the long run."

To be resilient and sustainable will require learning by observation of the farm, learning from research, feedbacks (both ecological and human, such as customer feedback and living wage feedback), in-service education, training and then evaluating all inputs and adjusting through management action. This cycle needs to be repeated again and again.

[7] I/we did not start out with a vision or plan of modules… it just happen as we sought to economically resilient. It was reading that made us realize that we were on the "right rail."

There is another aspect to scale. For example this plan requires that we remain below a half million dollars per year in gross sales or we will have to adhere to food safety regulations of the Food Safety Modernization Act of 2015. Those regulations do not make sense with regards to integrated pest management, sustainability and resilience. We depend on feedback from the community and bio- region as to the desirability of having us around to sequester carbon, provide healthy food and opportunity to social health with others in the community.

There is another aspect balance… we could become too diverse and loose efficiency with use of our resources…for example our human assets… like knowing enough about a module to be able to manage it. "On the other hand," if we have too few modules and we lose one module to an insect like SWD or perhaps a freeze, or a drought we would not be unable to maintain a living wage, contribute to economics of our community and community social health. Perhaps at some future time because of climate change, we anticipate that one module is just not working and we need to get rid of it for something else that, given conditions, is more stable and fits our core resources.

Likewise our identity may need to change over time, For now, it is small fruit. It is my hope that resilience and community will be the guide to a new focus or module. Some of our modules are very resistant to spring frosts, like mulberries for example, but susceptible to some other threat like SWD. But who knows a natural enemy may be "just around the corner." It takes years to grow a mulberry. Or perhaps we should be considering (test planting) serviceberry, a very early blueberry like fruit. Is the serviceberry fruit skin tough enough to resist the SWD? What of the plum curculio?

The Happy berry is ecological diverse, for example deep woods, corridors designed facilitate insect management, others for supporting native bees, a managed woods edge, open orchards and other areas with managed layered canopies, where old trees are/were removed bird houses of various types have been added, forage and perches for birds have been included even though some birds like robins are a major problem. Complexity is high…we encourage bird watchers on-farm and they will give us reports and teach us what we see or are not seeing. For example we think we see a slight trend for migratory robins to arrive later thus less damage to blueberries but at the same time see more local robins year round which teach the migratory flock where the local food supply is.

We would love to be globally autonomous and locally interdependent. This is a goal. We are afraid it will take global collapse for this to happen. There is a time to defend our modules with chemicals, infrastructure like wind machines and there is a time abandon them with a transition plan in between. I want to wrap up with some philosophical thoughts.

Our guide lines should be to shorten the distance from farm to plate, seek diversity both within a season of the year and between seasons and finally promote local processing. I believe that the future of our current and late capitalism is unsustainable. It is not sustaining our ecosystems on which our planet depends. It is not providing for exchange of resources and services with any form of biofeedback. It is working hard on many fronts to decrease our social health. We need to be working towards a moral economy in a commensally organized community using nature as a measure/guide as to what we do. We should retain the right to self protection of both the ecosystem and our

personal being yet at the same time “turn-the-other-cheek” and help all to understand all that we do…