A Systems Approach to Conservation Tillage of Forage Crops:

A California Dairyman's Perspective

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American Farmland Trust
Saving the Land that Sustains Us

Conservation Tillage Workgroup

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Because the environment is everyone's business

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Introduction

Since 1893 my family has been farming and milking cows in Hanford, CA. When my great grandfather purchased this land it was nothing but sagebrush, coyotes, and alkali soil. Back in those days, in order to develop the land they used a technique of deep ripping and flood irrigation to leach the salts down past the root zone to create usable topsoil. Since my great grandfather, grandfather and father milked cows in addition to farming; they had the added benefit of using manure as fertilizer. By using the technology and information available at the time, my ancestors were able to transform nonproductive soil into some of the most fertile land in the Central Valley of California. My story picks up where they left off.

In 2002 after spending 10 years off the farm I returned to the family business. During those years I had been working with computers and learned that when you start a new project it is important to begin with the most current information and technology. So when I started farming I wanted to see what the state of farming looked like at that time.

During the process of doing my research, my father applied for an NRCS grant for a reduced tillage program. In order to comply with the terms of the grant, we had to find ways to reduce the number of passes in the field to mitigate transient dust issues. This led to a study of the different technologies and practices available for conservation tillage.

The following information is the result of 8 years of research and practice in conservation tillage. This information represents my current understanding of the system and the practices that work for my specific situation. Like all farming, things are constantly changing and every practice does not work for every field. So please consider this a guide to help you get started. My hope is that you can start with this document as the current state of CT technology and grow it from here on your own. Good luck.

Systems Approach

One of the most important lessons I've learned in the development of a CT program is that you must develop a system. If you look at implementing individual practices, such as strip tilling, without considering other changes in your program, it is unlikely you will be successful. I have seen many farmers replace conventional corn practices with strip-till without considering how they are going to manage nutrients and weeds. This lack of planning usually leads to less than desirable outcomes. The farmer usually gets discouraged and develops a belief that CT doesn't work. If you are willing to spend a little time learning the systems of CT you will be successful. In my personal experience, once I had developed a system that worked, every new field I transition to CT actually shows an increase in yield the first year. In fact, all of my CT fields are out performing my conventional fields in yield and quality.

CT System Criteria

As I tried different practices it was necessary to develop some criteria as a basis for evaluating them. I had to have a way to quantify the value of a piece of equipment, practice, or technique so I developed the following criteria:

A CT system must:

Be economically sustainable —
I have always had the attitude that helping the environment MUST be profitable. There is no reason to sacrifice success in order to achieve sustainability and be a good steward of the land, water, and air. Therefore, the CT system must be profitable. Not only must it be profitable, it must be more profitable than my conventional system. This is called progress. Every businessperson wants to streamline in order to become more efficient and profitable, it's what drives us. If you are interested in changing the world for the better, make the change you seek the profitable thing to do.

> "Conservation tillage requires different equipment, different management practices, and most importantly a different way of viewing what is happening in your soil."

Increase yield — Planet Earth has a finite carrying capacity. That is the planet's ability to provide food for the species roaming around on it. There have been several studies of the Earth's carrying capacity and the results range from 2.5 to 15 billion people, depending on technology. I'm not sure what the actual number is, but I do know that in order to feed a growing population on a shrinking amount of productive land we must constantly strive to increase yield and nutrient density. In my opinion, every farmer has an obligation to live by a Hippocratic oath of sorts to do more with less.

Improve soil quality — My great-grandfather started working this land more than a century ago and his goal was to improve soil quality in order to feed his family. My goal is to leave this farm to my son in better shape than I found it, which was pretty darn good. Any component of the system must promote balance in biological entities like microbes and earthworms, minerals, nutrients, oxygen, water, and organic matter.

Reduce inputs — The system must reduce inputs including tractor passes, diesel, equipment to own and maintain, fertilizer, pesticides, labor, and water. Remember that EVERY input costs you money. The goal of the CT program is to become more profitable while conserving resources and taking care of the environment.

Reduce emissions — The primary environmental benefit of CT is reduction of emissions. The CT system must reduce particulate matter (dust), VOC's (smog), and now carbon is coming into this equation. This whole carbon racket is a good example of my earlier statement of environmental solutions must be profitable. As a farmer I think it is a good idea to sequester carbon in the soil, because it's good for the soil and the plants. The government seems to think that despite being the most abundant element in the universe, carbon is a pollutant. I believe carbon has more value in the ground than in the air, so it is in my interest to sink as much of the stuff as I can in the soil. This has nothing to do with the climate.

The System

In order to explain my CT system it is necessary to understand my conventional program. The following describes the difference in passes between my conventional program and my CT program.

Currently my CT program is performed exclusively on double-cropped dairy forage. We grow wheat in the winter and corn in the summer. The following outlines the tractor passes for each program.

"The primary environmental benefit of CT is reduction of emissions."

Table 1: Conventional Passes vs. CT Passes

Conventional Tillage	Conservation Tillage
Wheat to Corn 1. Rip / Chisel 2. Disk 3. Disk 4. Lister / Disk Bedder Pre-Irrigate 5. Cultivate Beds 6. Cultivate Beds 7. Roll Beds 8. Plant into moisture 9. Cultivate Corn 10. Cultivate Corn 11. Side Dress Fertilizer 12. Spray Mitecide w/ Roundup **Corn to Wheat** 13. Spread Composted Manure 14. Disk 15. Disk 16. Drill wheat 17. Spray Herbicide by Air	**Wheat to Corn** 1. Strip Till Pre-Irrigate 2. Plant with on-seed and banded fertilizer 3. Spray herbicide 4. Spray Miticide and herbicide **Corn to Wheat** 5. Spread Composted Manure 6. Disk 7. No Till Drill 8. Herbicide Spray by ATV

Net Pass Reduction for CT System

Conventional Tillage

11 Dirt moving passes / year

Vs

Conservation Tillage

1 strip till (partial dirt moving)

1 disk (complete dirt moving)

= Net reduction of 9.5 dirt moving passes per year.

87% reduction in field passes

Technologies Necessary for CT System

People often ask me if conservation tillage is so beneficial to your bottom line and yields, then why haven't people been doing it before now. There are two answers to that question. The first answer is that people have been practicing some form of conservation tillage for more than 30 years in the mid-west. CT has only recently been adopted in California for a variety of reasons that I will outline later in this document.

The second answer is that for CT to be practical it requires a number of fairly recent technologies. It is the combination of these technologies that have allowed me to develop my system. I think it is possible to develop a CT system without some of these technologies but it would be very difficult. The following section describes each necessary technology and their use.

Figure 1. Orthman 1tRIPr

Strip Tiller — My CT corn planting practice of choice is strip tilling. Strip tilling is a pre-plant land prep process where the soil is tilled in narrow strips rather than tilling the entire field. Most strip tillers chain together four processes.

First you have a residue manager to cut through or push plant residue out of the way.

Second there is a shank that vertically tills for the purpose of shattering the compaction layer.

Third, there is a set of wavy coulters whose purpose is to close the trench created by the shank and help to shatter rocks.

Finally, there is some form of clod management apparatus such as a squirrel cage or flat roller.

GPS \ auto steer — Strip-tilling is a precision practice. The strip tiller only tills a space about 13" wide every 30" in the field. It is important to have an auto steer system with sub-centimeter (RTK) accuracy and repeatability. It is important that the tractor you use to pull the strip tiller and the tractor you plant with and side dress with are calibrated. The best option is to use the same tractor for all three passes or have a GPS system that allows you to import field data and way points from earlier passes. This will ensure you get the planter lined up on the strip every time. We spent a lot of time struggling with sub-

Figure 2. Schlagel 'Till and Plant'. (http://www.schlagel.net/Till-N-Plant.htm)

Figure 3. Planter on strip till field.

standard GPS systems before finally getting it right.

GMO corn — Probably one of the most important technological breakthroughs supporting CT was Roundup Ready corn. The primary purpose of cultivation is to manage weeds. The Roundup Ready corn eliminates the need for cultivation passes. I have been trying to figure out a way to do Strip till and CT without the use of Glyphosate but haven't come up with anything practical yet. If you can think of something, let me know.

Modern corn planter technology — While it is not necessary to have a no-till planter to plant into strip-tilled ground, it helps. Some of the technologies we use while planting corn that differ from my conventional corn planting are:

Down pressure springs/airbags — Since we are planting into strips and there is residue and hard packed soil between the strips the planter ride can be a little rough. The down pressure springs or airbags help the planter maintain positive contact with the ground which leads to more consistent seed planting depth.

Figure 4. Down pressure airbags on John Deere corn planter.

Figure 5. Suncos residue managers.

Residue managers — Residue managers are used to help move residue that migrated into the strips during pre-irrigation. They also help break up the crust that develops on top of the strip which gives the planter access to moist soil and helps the closing wheels do a better job.

In furrow liquid delivery system — In furrow nutrition is not exclusive to CT. I believe early nutrition is necessary for success in any corn planting application. I think of in furrow fertilizer as colostrum for corn. Just like a calf needs colostrum in it's first day of life in order to develop it's immune system and maximize it's growth potential, corn needs certain nutrients available in the first 10 days of it's life in order to set itself up for maximum yield potential. You can certainly screw up yield after corn gets a good start but you can never fix a bad start once you have screwed that up.

Seed firmer — The seed firmer is another technology that is not exclusive to CT but helps. One advantage of conventional tilled soil is that it is very loose and mostly free from residue. As a result you tend to get pretty good seed to soil contact. With no-till and strip till, you are dealing with a slightly more complex seed environment and want to make sure your seed has good contact

Figure 6. Tractor mounted with liquid fertilizer tanks.

with the soil. That is where the seed firmer comes in. The seed firmer is attached to the planter between the disk openers and drags across the bottom of the trench. The seed is dropped in front of the firmer and the firmer presses the seed into the soil.

Figure 7. Keeton seed firmer on corn planter

Aggressive closer wheels — In order to achieve solid closing of the seed trench it is important to use a closer wheel that can exert some force on the trench and close the trench in from the sides. I like the closers made by Schlagel or a similar product.

In my system, the process goes like this, the disk opener opens the trench, the liquid fertilizer is laid down, the seed is dropped on the fertilizer, the seed firmer pushes the seed into the soil and fertilizer, then the closer wheels cover it up.

Figure 8. Schlagel closing wheels.

Rolling fertilizer side dress bar — When I first started CT I was only doing it on land that was connected to the dairy where I only fertilized with manure water. Once I moved off the dairy with strip till I had to find a way to deliver fertilizer to the ground so we put together a rolling fertilizer coulter bar. Our old fertilizer bar used shanks and shanks won't work in CT because of the compacted area between the strips.

> **"Best results have been found with a drill that has double disk openers with down pressure springs"**

No-till drill — Best results have been found with a drill that has double disk openers with down pressure springs. Springs are necessary to cut through corn stubble and maintain positive contact with the ground traveling over rough terrain.

"Managing harvest compaction can be tricky."

Figure 9. Sidedress bar on planter.

General Ideas to Consider in Transitioning to CT System

Managing Compaction –

Use lighter equipment; flotation tires or tracklayers –
Since we quit ripping and disking between every crop we hardly ever use the big tractor anymore (255 hp). I pretty much am doing all my farming now with 1 tractor (195 hp). Lighter tractors exert less impact on the ground. We use narrow tires to plant corn since the tires ride in the area that has not been tilled.

"...switch to trailers with flotation tires rather than trucks if your fields are close enough to the dairy..."

Use traffic lanes via GPS – The idea of traffic lanes is to always drive in the same spot with every pass you make. With GPS you can do this as long as all your equipment is the same width or at least multiples of each other. (ex. 20 foot planter, 40 foot spray boom) Since we harvest for silage and have custom choppers with semi-trucks do the work, it is difficult for us to use traffic lanes. Traffic lanes are common practice in the mid-west where the farmer does all his own work.

Harvest Compaction – Managing harvest compaction can be tricky. Some tips include, switch to trailers with flotation tires rather than trucks if your fields are close enough to the dairy; time your last irrigation so that the ground is dry enough to support the equipment

"After a few years of CT your fields will increase in organic matter and biologicals like worms and microbes"

Spongy soil structure – after a few years of CT your fields will increase in organic matter and biologicals like worms and microbes. These constituents of the soil will improve structure to a degree that over time the ground will develop a spongy texture. I was told this many years ago and didn't believe it until I saw it in my own field. After harvesting a 4th year field of CT corn, the ground had some wheel marks from the silage trucks. I went back to the field a week later and I could not find a track. The soil had sprung back. This doesn't work very well, however, if you harvest with the soil too wet. Timing is key.

Water Management

It is important to note that we are 100% flood irrigated. All the information I provide below relates to this irrigation practice. It is my understanding that overhead irrigation and sub-surface drip make conservation tillage much easier. If you use one of these forms of irrigation you are already ahead of the game.

> "It is important for water to move off the field quickly in order to keep adequate oxygen in the root zone."

Field slope — over the past 40 years or so my father has been scraping fields flat by flat. Flat by flat fields have no slope in either direction. On our soil type with short irrigation runs, this makes irrigating very easy. However I am finding that these fields are not ideal for flat-planted corn. It is important for water to move off the field quickly in order to keep adequate oxygen in the root zone. The fields with slope drain quicker, therefore water stands less, increasing yield potential.

Return systems — Return systems are important for the same reason stated above, the faster you can move the water off the crop, the better off it will be.

> "Timing is critical, I can't say that enough, timing is critical."

Soil Moisture and planting — I have found that timing is much more critical in planting heavier soil than in the lighter soil. The sandy soil is forgiving, doesn't crust over, and closes well. With strip-till you don't have the advantage of knocking beds down to get to moisture. Timing is critical, I can't say that enough, timing is critical.

Water Use — Since the space between the strips is more compacted than the strip zone, water will take the path of least resistance and penetrate deeper into the strip than the space in between. I believe this helps reduce the amount of water I use per crop. I know this because after ripping a field, the first irrigations takes 2 to 3 times longer than the 7th irrigation. Each irrigation gets faster until around the 4th when they start to level out. With strip till, every irrigation takes the same amount of time. One thing we know from digging holes in the field is that deep soil moisture is preserved from previous crops because ripping or disking did not disturb the soil.

Nutrient Management

Rolling fertilizer bar — If you need to incorporate nitrogen or other fertilizer there are many ways to get it into the soil, with the strip tiller, the planter, or with a rolling fertilizer bar. We apply an on-seed startup fertilizer with the planter the follow up with a side dress application of UN32. In order to get the UN32 into the soil without disrupting the strip, we use a rolling coulter fertilizer bar.

Compost manure — I believe it is always best to compost your manure. Composting reduces the mass and moisture of the manure making it lighter and more consistent to spread. Composting also sterilizes the manure and helps to eliminate weed seeds. We use the loader to turn the piles and monitor the internal temperature. We add water to it as it cools down to kick start the process a couple of times..

Fall manure application — We incorporate all our manure in the fall. We use the summer heat to help the composting process then spread prior to wheat. Another advantage of fall spreading is that the nutrients have time to breakdown in the soil and become available to the corn in the spring.

To Incorporate or not? — I have tried it both way and for now we are disking the manure in very shallow no more than 2–3".

Pay attention to soil balance — often in a dairy nutrient management plan we are focused on Nitrate and ignore the other macro and micro nutrients included in the soil. It is important to monitor annually the composition of your soil and try to make decisions to keep the soil in balance with nutrients and pH. High levels of P and K can develop in heavily manured soils and high levels of these nutrients can tie up the availability of micro and other nutrients to the plant limiting yield. It is important to rotate with crops such as Alfalfa and Cotton in order to keep the soil in balance.

Add Gypsum to compost — I am currently exploring the option of adding gyp to the manure piles during composting. This practice is supposed to help the decomposition process and it gives your gyp a free ride to the field. Increasing the amount of Calcium in the soil is always a good idea for soil structure and water infiltration.

Pest Management

Pesticide Timing — timing of herbicide spray is crucial with CT. When you pre-irrigate and plant corn into moisture, your weeds get about a 3 week head start on the corn. We time the first application of Roundup within a few days either side of planting, depending on each fields weed pressure. It is important to kill the weeds before the corn emerges so they do not impact the corn plants. We will typically irrigate the corn 10-12 days after emergence with a quick shot of water. This will germinate any remaining weeds. By the time we are ready to spray for mites, which is usually around 4–6 leaf collars, we can include another application of Roundup with the miticide to kill the late emergent weeds.

Own your own sprayer — I have heard it said that a sprayer has the shortest payback of any piece of equipment you will ever buy. I believe it. With strip-tilling it is absolutely crucial you spray each field as needed. When we first started this process we relied on commercial applicators and had a big mess. The applicators do a good job, the problem is you can't get them to come to 20–30 acres at a time on the exact day you need them. My opinion is that if it takes you a week to pre-irrigate a field, it should take you a few days to spray it. Often times if you wait for the later weeds to germinate the early weeds are already too big to control or impacting your crop. I do hire a commercial applicator to spray for mites. The timing on this application is a little more flexible than the early application.

> "With strip-tilling it is absolutely crucial you spray each field as needed."

ATV sprayer — a few years ago we purchased an ATV sprayer. Depending on your size, my opinion is that ATV sprayers are the best bet. They are light and cause almost zero compaction, they are easy to operate, and they are cheap. We use the ATV sprayer, which is actually an 18 hp Kubota tractor with flotation tires pulling a 40 boom sprayer with 150 gallon tank, to spray all our alfalfa, roundup on corn, and the herbicide for wheat. We drive right over the top of the growing wheat and a few days later you can't see where the rig drove through the field.

> "...my opinion is that ATV sprayers are the best bet."

Scout your fields — like with conventional corn and wheat it is important to scout for pests at least twice a week. Early detection and mitigation is the key to maximizing yield and protecting your crops from pest invasion. We generally spray for invasive pests by air because usually they come when the corn is too big for ground rigs.

Other Practices Currently Implementing

Twin Row Corn — I have been experimenting with twin row planting of corn. In twin row corn each 30" row has two planter row units. The units are spaced about 7.5 inches apart and the plants are staggered in a zig-zag pattern. The advantage of twin row is that you utilize a higher percentage of each acre of land. This provides each plant with more space to develop roots, more sunlight, and more access to moisture. With our twin row program we tend to increase plants by 2000–3000 plants per acre which has given us a 3–7 ton per acre increase in yield without sacrificing feed quality.

Thank you for taking an interest in Conservation Tillage. I hope you have learned something from this paper and hope that you have great success implementing a program of your own. Lately I have been calling what I do Biological Farming rather than conservation tillage since CT describes only one part of the system. Biological Farming is the entire system of growing forage crops with the land and the cow in mind. There is a great book on this subject called, "The Biological Farmer" by Gary Zimmer. I highly recommend it.

The definition of Biological Farming is:

To work with the systems of nature to develop a farm which is environmentally sound and which leaves the land, water, plants and animals in a healthy, productive state for all future generations.

Dino Giacomazzi, Hanford, CA, May 2010