Farming Is Not Big Gardening

A Story about Modern Production Agriculture in the United States

Thomas C. Mueller

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I sincerely thank my wife and my children for providing ideas and critical reviews of this book. I also thank several anonymous technical reviewers for providing technical correction where needed.

TABLE OF CONTENTS

PREFACE

Doubting Thomas said "Unless I see the nail marks in His hands, put my finger where the nails were, and put my hand into His side, I will not believe."

Whether you believe this story or not, I provide it here as an illustration of others' doubting. Many Americans, Europeans, and Japanese simply do not trust groups they previously thought were trustworthy. Phrases such as "I'm from the government and I'm here to help you," "I did not have sex with that Lewinsky woman," "I'm not a crook" (Richard Nixon, in case you did not know), and the list goes on and on. With respect to this topic, the only absolute truth that I can be sure of is that all people lie; people have an agenda.

Trust can be defined as "firm belief in the reliability, truth, ability, or strength of someone or something." But within this definition there still is an essence of subjectivity and doubt. My wife and I have watched British murder mysteries on Netflix, including for example *Poirot* and *Midsomer Murders*. In these stories detectives search for a motive or reason for each murder. Apparently, there are three basic motives for murder: money, revenge, and sex. While lying is not the same as murder, the same motives may be involved in why people lie.

I have learned that the best long-term policy is honesty, although this can be difficult. As a newly married person years ago, my wife and I were still getting to know each other. One night she prepared a new recipe of honey-glazed chicken for dinner. To my taste it was not very good. When she asked me about it, I lied and said, "This is very good, Honey," (to spare her feelings). Just a few days, later she made the same dish again. When I was honest about my true opinion of the dish, she was hurt. We should always try to be respectful of other peoples' feelings, however, insofar as it is possible, honesty is the best policy.

I am asking you to trust me.

This book is about food and what we eat. My view is that what some people believe about food must come from fairy tales, since it is ridiculous. I also know that "scientists" each have their own agenda, and they may self-select

data or ideas to support the view that their specific research will save the world, stop global warming, cure cancer, or whatever else they have to say to get their project funded. In some cases it may even be true! If you think academics are "pure as the wind-driven snow," you simply do not know any college professors. (I can say this since I am a college professor.)

My goal with this book is to make you laugh (some) and to share with you some ideas about farming, food, and the myths and fables that surround this important topic. In the spirit of full disclosure, I do not purposely set out to perturb you, although to be honest that will probably happen. As a "foodie," you simply may not understand the difference between spirit-filled beliefs and cults. For you nerdy intellectuals, I do not care how many scientific papers/studies or statistics you bombard me with: I simply do not believe you. My name is Thomas, and there was this guy in the Bible named Thomas, and he doubted others until he was shown absolute proof (to him personally), and so do I (please see previous page for more details). I have used this saying many times in my life, "It is nothing personal, but my name is Thomas, and I simply do not believe you." (It can be quite comical to see the look on scientists' faces when you doubt their cherished views.)

To you, the reader of this book; firstly, I hope you enjoy it; secondly, I hope that you believe me and that you trust me to share an informed perspective on a topic of great importance to all of us.

Thanks for reading.

Thomas C Mueller

CHAPTER ONE

INTRODUCTION

People believe things for a variety of reasons. I'm always amazed how a person's perspective dramatically affects what they see. I always find it amusing when people say, "I have no bias," because everybody does. In my immediate family, there are several rabid college sports fans. To watch the game with them reveals that different people can watch the exact same event and see something completely different. In my experience, many times people see what they want to see. To use a line from a movie called *Second-hand Lions*, the actor Robert Duvall says, "Something doesn't have to be true for you to believe it. If you want to believe in something, just believe it."

The Internet is a great thing. It is just not always factually true.

I wrote this book to provide a viewpoint on agriculture in the United States, something I know quite a bit about. Disclaimer: I freely admit my view is not the only valid viewpoint, but I offer the suggestion that I might know more about it than some. I grew up on a farm in Illinois, I worked for several companies selling the supplies farmers need to grow their crops, and I have 3 college degrees in agriculture: Bachelor of Science (BS) from the University of Illinois in Agronomy (tell me if you have ever heard of that degree), Master of Science (MS) from the University of Kentucky in Crop Science (as opposed to Crap Science, which specializes in fertilizer), and a Doctorate of Philosophy (PhD) in Crop Science from the University of Georgia. I remember my dad commenting and telling the story to other people, "Lemmie get this straight, Son. You took four years for your BS, two years for your Masters and three years for your PhD. So nine years of college… Son, I believe you are educated beyond your intelligence." Note: having worked with many PhDs over the course of my adult life, I can absolutely agree with my dad on this matter. Besides my formal education I've been involved in agricultural research and teaching undergraduate and graduate classes for more than 25 years. I work with the crops of corn, soybeans, wheat, rice, canola, cotton, tomatoes, and

vegetables. I have also conducted research in turf, pastures, rights of way (think roadsides and power lines), and tried to kill poison ivy plants. I've traveled to five of the seven continents and visited farmers on each of them, and many times I am asked to speak at meetings concerning agriculture in the US.

I've also eaten almost every day of my life.

Food and its production is NOT the same as any other commodity. A proverb from an unknown (to me at least) source goes like this: After one day with no food, a person will ask for food. After two days with no food, a person will beg for food. After three days a person will steal for food. After four days without food for himself or his family; a man will kill for food. Using this analogy, we are five days away from anarchy wherever humans live at any point in time. I believe many of the "political" revolts in the last few years (for example, the Arab Spring) happened after food costs greatly increased and food availability decreased. I believe it is safe to say that hungry people will riot more easily, since hunger is a powerful motivator.

Notes on this book: I have a few references to other books listed as I go along, but this book is not fully cited. You either believe me or not. I invite skepticism, but I hope you like reading this tome.

I realize people of various views will (hopefully) be reading this book. An example of a large dichotomy is those that believe some sort of *guiding hand* "created" our world and us. Another view is that our planet coalesced from matter, asteroids brought water to our young planet, various processes occurred so that humans evolved into our current state. At times through this book, I will denote these as a dual nomenclature, something like created/evolved… since no one can prove which pathway is correct. (Would be nice if we could to do an experiment on that, but with only one Earth, I'm not sure how to conduct that research).

I guess people write books for a wide variety of reasons. I have written many shorter pieces of prose, often highly technical in nature, but this is my first attempt at reaching a broader audience. I was reared on a farm in a very rural, isolated, back-woods part of southern Illinois, in a town that you never heard of. I used to tell people that to get to where I am from originally, you go to the sticks and then go a few more miles, and that's where I'm from. From the house I grew up in as a small boy, you can look straight south and see a massive smokestack from a recently constructed

coal-fired electrical generating plant. There is a concept shared by many Americans that when they don't want something close to them called not in my backyard (NIMBY). Why is this coal-fired power plant there? Because nobody who lives there had the ability or desire to stop it. It also sits on top of a large coal reserve and so it is easier to move electricity rather than the coal.

Growing up in a rural farm-based economy I was intimately connected with agriculture, farmers, and food production. I had cousins that came from the city to visit the home farm, so I knew that there was this other group of people out there (we called them city slickers) who didn't really understand farming. As the population of the United States becomes more and more urban with no family connections to anybody on a farm, the disconnect between the people who eat the food and the people who grow the food widens. People in the cities are ignorant of what farmers do. There's nothing inherently wrong with this. Many people are ignorant on a great many things. I really don't know how my cell phone works, but it sure is nice. I'm not sure how the traffic lights know how to turn different colors and how they don't all turn green at the same time, but I'm glad that that doesn't happen. The difficulty is when people who are ignorant about something, like food and its production for example, make decisions about what type of food they are going to eat and what type of food they are going to buy. This is why I wrote this book. I hope to make a little money on it too, but don't tell anyone.

I also wrote this book because it is something I've wanted to do and my wife (who is smart and beautiful, although one must question her judgment on "mate selection") supported this endeavor. I hope you enjoy reading it (it was a pain to write) and hopefully you may see food and farmers a bit differently.

CHAPTER TWO

ALL CROPS ARE GMOS

First off, before you yell at me, I like dogs. We had many dogs growing up on our farm. Some were for hunting (rabbits and raccoons mainly), and others were for pets (for protection-our dog named "Pal" was one half German shepherd and half full size collie… a big dog). I like dogs. Dogs hold a special place in our American culture, being held in higher status than other species. Dogs are often considered a family member, and when one passes it is a time of sadness for that family. Some dogs are gifted to directly help us humans as therapy support dogs, and these dogs can bring great joy and happiness. I believe dogs go to heaven. Maybe not all of them, but the good ones do.

All dogs have 78 chromosomes. Humans have 23 sets of two for a total of 46 chromosomes, for reference. All dogs are descended from a common ancestor, more or less a wolf. Over thousands of years humans selected various traits in the puppies, such as size, speed, disposition, color, and so on. The humans imposed a selection pressure and thus genetically modified the dog species. As different dog breeds are not the same, they are genetically modified, genetically engineered, selected, bred… Pick whichever verb you want. The original "type" still exists, but many current dogs often bear little resemblance to the ancestral prototype.

Crops are the same.

Crops grown for energy (corn, wheat, rice, potato, etc.) or for protein (soybeans, dry beans, etc.) have been selected over thousands of years by our human ancestors. For example, a certain stalk of "wheat" yielded more, tasted better, or survived a drought (or another other stressor), and so the "farmer" saved that seed and planted it next time. Over many selections/generations, the crop was genetically modified. If we fast forward to more modem times, scientists can take genetic material and insert that material into an entirely different species. Genes from bacteria can be placed into a plant. Not delving into the technical specifics of how this is done, the resulting final plant type is called "transgenic." I believe

that the real issues/concerns/ignorance that most people have about GM●/GE (genetically engineered) crops actually relate to transgenic plants.

The truth is that "heirloom or heritage" variety vegetables are genetically modified (GM), compared to original types. In reality, lots of "bad" genes/traits have been bred/selected out of these plants. Yet, consumers do not fear GM heritage vegetable varieties. Now, why is that? As traits are selected via "conventional" breeding techniques, positive traits of interest often provide a direct benefit to the consumer, such as taste, quality, and aesthetics. In contrast, most transgenic crops provide only an indirect benefit. For example, transgenic crops that tolerate post-emergent (after the crop has emerged) glyphosate application have been a huge benefit to farmers, but the consumers derive no direct benefit. Glyphosate is a herbicide used by many, with one of its tradenames being Roundup. Maybe you have heard of it? ●ther transgenic crops that express a *Bacillus thuringiensis* (BT) protein in their plant parts decrease crop losses due to certain types of insect pests. The use of these BT crops can greatly reduce the use of synthetic insecticides in these crops, but this is of no direct benefit to the end consumers. The transgenic crops are said to be "substantially equivalent" to conventional varieties, and thus they are the same, at least to some people.

Later chapters will discuss in detail how some nongovernment organizations (NG●s) have vilified "big bad chemical companies" and their exploitation of sales of transgenic crops (chapter 3), how RoundupReady crops changed American (North and South) agriculture in the last 2● years (chapter 12), and how transgenic crops are viewed quite differently in the US compared to Europe (chapter 13).

I realize some of my ideas are mere semantics, with GM●/GE contrasting starkly to transgenic terminology. Recently, I have seen that the Food and Drug Administration (FDA) has proposed the term BioEngineered (BE) to label GM● food items. I am amazed at the profound ignorance of virtually all American consumers (and others around the developed world) with respect to food production and what they are consuming. For example, I see the term gluten-free posted on products that there is no chance of having a wheat protein inside of them. Gluten-free orange juice is nonsensical, but a myriad of illustrations just like this are common. In the absence of understanding, it is normal and expected to assume and to be concerned with dire, negative outcomes. This is how some NG●s thrive.

CHAPTER THREE

NGOS ARE BIG BUSINESS

Let's start with defining some terms. An NG● is a nongovernment organization, sometimes referred to as a non-profit organization. An NG● often has a 5●1C3 designation. 5●1C3 is a tax-exempt status afforded to many NG●s, which allows them to accept charitable contributions and to pay no federal taxes upon these contributions. A nonprofit organization is a group not driven by greedy capitalistic motives to maximize profits (see also 5●1C3).

There are many NG●s, and they differ in many ways. A small local NG● may be involved with feeding homeless people in a small town. Some NG●s have international goals and ambitions to save the planet from environmental degradation, global warming (oops, I mean climate change), or other societal issues. Some have modest finances and others have substantial fiscal resources. An NG● is a vehicle for a group of people that are concerned about a given topic to focus their efforts to improve the outcomes and lives of those affected by that given topic.

As a professional that has taken a number of formal classes on how to manage nonprofit organizations, (yes they have classes on this), I can assure you that most nonprofits need money to operate, and the more money, the better. Nonprofit organizations often have costs like employees or offices, etc. As one of my instructors succinctly put it, "No margin, no mission."

I guarantee you that virtually every NG● is sincere in their beliefs, their viewpoints, and their agenda. There is nothing illegal, unethical, immoral, or wrong in the NG●s and how they operate. Also, there is as wide a diversity of causes and interests in NG●s as there are people. I wish to share some perspectives on some NG●s to provide a background for how some of them operate. To facilitate our discussion let us contrast three types of people. The first works for a private company, the second for a university, and the third for an NG●.

The first person sells pesticides to farmers and so derives his paycheck from sales of products. He/she sells a chemical, the farmer pays for it, money flows to the company, which can then afford to pay him/her, do research, pay taxes, etc. It is a pretty straightforward flow in which the company makes a product that it sells to the farmer so that the farmer derives a direct benefit from and is willing to pay dollars for that service or product.

Now, the second person will be me personally (egotistical yes, but why not?). Dr. Mueller is a tenured professor at a land-grant university (originally these universities were established to conduct research and distribute information to enable agriculture to feed our young nation). My salary comes from state funds, and the university receives funds from the federal government based on a formula (number of farms in our state, total sales of ag products, and various other parameters). I am encouraged to solicit "external" funds from government grants, but I also solicit and accept funds from chemical companies (like person number one's) and various commodity groups (NG●s of soybean or corn farmers). These extra funds pay for my staff, my research supplies, my travel, etc, but not my salary. My salary is "hard money." My boss may not like it if I bring in no external money, but I still get paid.

The third person works for an NG●. Funding for NG●s can be highly variable. The NG● may get grant funds from a government agency (yeah, I know this sort of contradicts the name), may get money directly from private individuals, or may get money from foundations or generous corporations. You can go to any large NG● website and quickly figure out how to donate money to them. They make it easy and simple. This fundraising is key to NG● survival and success. There is nothing wrong with that, but that is the way it is. Now let us contrast the flow of money for our three amigos (not really correct terminology, but why not?).

Person #1 one sells products, money flows to company, person number one gets paid. Person #2 does or does not do his job, money flows to university, Person #2 gets paid. Person #3 solicits funds, money flows NG●, which pays Person #3. Let us examine these three money flow paths. In number one, a clear connection of how money flows: Person #1 sold the product, which will provide the benefit for which the farmer pays money. Number two, money flows independent of activity. The public has decided that the public university and faculty salaries are funded on a recurring basis. (I think this is a very good idea for personal and professional reasons). For Person #3, a private person can choose to send

money on an elective, voluntary basis. But why does this happen? The NG● must provide a compelling reason for a person to donate. To do this, the NG● must highlight/advertise/promote a problem or an issue. They have to get people (or other groups) to care about their problem/issue enough to give money. I offer the opinion that one NG●s problem can be viewed from a different perspective by other NG●s, government agencies, or companies. Also, the original NG●s pitch really must connect to the potential donor on an emotional level. Stating a cold, impersonal statistic often fails to elicit a sufficient response, while color pictures of shivering cute puppies or of malnourished starving children can open the pocketbooks and can fill the coffers of the NG●. Note: I like puppies, and I wish all humans had adequate food. I'm not saying you should not donate to NG● causes. I would offer the observation that the corporate reports of some NG●s are pretty impressive.

The Environmental Working Group's (EWG) annual report shows a total budget of ~12.6 million dollars in 2●16 with three sets of offices (Washington DC, Iowa, and California). I am not sure how much the director makes, but the website is very easy to navigate. The Natural Resource Defense Council (NRDC) has an annual budget of ~14● million dollars and has offices in New York City, Washington DC, Chicago, Bozeman (Montana), San Francisco and Santa Monica, CA, as well as Beijing, China, (not too sure why "our" NRDC needs an office in China, but I did find that interesting). The budget seems pretty big to me. Based on my examination of their annual reports I could not find the various titles or job functions to show the salaries that the directing supervisors of the EWG or the NRDC make, but they do list all their public directors. Lots of smiling faces, to be sure… I'm sure the people who work there earn their pay for operating these large NG●s. I find it interesting that that is not what they highlight in the direct solicitation for funding from you, the private individual.

Concluding thoughts on NG●s: by definition, a group of people forms an NG● because a company or government agency is not fully addressing this group's specific concerns. Members of a given NG● may be very strongly connected and may be zealous in their passion of their respective concern/topic/cause. ●nce a given position/perspective is obtained/derived by an NG● supporter, to change that perspective is difficult or even impossible. ●ne reason I am writing this is to provide an opinion on agriculture. I am pro-farming, pro-food, and I wish to maintain the long-term sustainability of agricultural production systems. That being said, let's talk about farming next.

CHAPTER FOUR

THE JANUARY GARDEN

In the title of this book, I use the term gardening, so I thought I might share a few ideas on what this means to me. The *English Oxford Living Dictionary* (the publisher that has agreed to publish this book is based in England, so I thought I'd better use a British dictionary to keep them happy) defines a *garden* as "a piece of ground adjoining a house, in which grass, flowers, and shrubs may be grown." This is in contrast to the definition of *gardening*, which this dictionary defines as "the activity of tending and cultivating a garden, especially as a past time." I find it interesting that a garden is defined as a location, while gardening is defined as an action that a person does.

An essential premise of this book is the contrast between farming and gardening, so this chapter is going to establish the basics for what I see as gardening, which I see as one of the most positive actions a human can possibly undertake. If, after reading this chapter, you think I'm not a really huge fan of gardening, please know that nothing could be farther from the truth. I have a small garden which adjoins my house, and I take great joy in picking strawberries and asparagus from my small plot.

Farming is a technologically challenging, complex, capital-intensive business that people try to make money at under extraordinarily trying circumstances. Gardening is a choice. A choice full of leisure and enjoyment. Gardening is a largely optional, daily activity for a person who chooses to do so. Farming is a lifetime commitment of long-term investments in equipment, expertise, and thousands of hours of effort. Gardening is a source of joy to those that choose to spend their days in their gardens. It really would not make a lot of sense if you absolutely hate gardening to spend a lot of time doing something that you really don't like. This view of gardening self-selects among the population so you don't do it, unless you really want to garden. If you don't want your grass to look good, you pretty much just have to mow it every couple weeks, and that's about all you have to do, depending on the covenant (rules) of the subdivision in which you live. Side note: many of my friends and

acquaintances know that I control weeds for a living. Given this familiarity, I frequently get requests for advice on various situations, even though there are times I have no idea what the correct answer is in the given situation. To illustrate, I got the following text last November:

"What do you suggest to kill dollar weed (*Hydrocotyle umbellate*)? We're at a friend's in Florida and their HOA (homeowners association) is after them for having dollar weed in their lawn."

Well, the truth is, I have no idea what dollar weed is or any idea how to control it. I texted them back and said I would check into it and respond later. After a few days, I contacted a former student of mine who lives in Florida, and he suggested several herbicidal options which he thought would be very effective in controlling this weed. I sent that information on to my friends, and they were pleased to help provide information for their friend. Why the person didn't just Google dollar weed control on the internet I don't know, since the information is probably right there. Maybe they just trusted my recommendation, I guess.

Another difference between farming and gardening is the cost of entry into the activity. To start a garden needs minimal resources. There are opportunities for gardening even for apartment dwellers who have a terrace or an open deck where you can grow plants in small pots and containers. For homeowners, it's simply a choice of tilling a small plot of land and planting some seeds in an area, then tending them and caring for them through maturation and picking. To get into farming, by which I mean broad acre crops that I have discussed in other chapters, takes a huge amount of capital investment, something in the order of millions of dollars. This is one reason why almost all people who are currently farming inherited a substantial amount of their capacity (land and equipment) from previous generations or relatives who were farmers. This is not necessarily bad, but this is the way it is. If a person who graduated from high school or from college decided she/he would like to be a full-time farmer, she/he would find the cost of entry would probably preclude her or him from immediately beginning a full-size farming operation. This is not unique to farming. If the same person wanted to open up a factory to produce a given commodity item, they probably couldn't borrow enough money either. Farmers operate large businesses.

Gardening is often a visual display of a person's interest and giftedness with growing plants. Although I have no statistics to back this up, (I never let the lack of data stop me from drawing conclusions before, so why

should I start now?) my guess is that there are more flower gardeners than vegetable gardeners in most cities in the United States. People will grow small plots of flowers (often referred to as flower beds), shrubs, flowering trees, ornamental trees, maybe have some flowers in pots on the porch or deck, or maybe houseplants, rather than grow vegetables that they will eat later. For one thing it's just too easy to buy vegetables at the grocery store. No tilling, planting, weeding, watering, (insert seven steps here), and finally picking the produce involved if I just go to the store and buy it; oops, I forgot, cooking it! As opposed to a visual display of beauty (I remind you that beauty is in the eyes of the beholder and to a fly a pile of manure smells wonderful), the flowers provide delight on a continuing basis. The flowers provide days, weeks, months, perhaps even years of visual enjoyment to the gardener. It also tends to be easier to find different plants that wildlife will not destroy if no one is going to eventually eat them. The gardener that is really set on growing eggplant to eat (why anyone would eat eggplant, I have no idea), knowing they have various wildlife in their garden area that will consume this plant is really going to be challenged to grow the plant to maturity and harvest it. As opposed to flowers, where you can keep planting different flower species until you find something that the deer, rabbits, etc. simply will not eat.

I'm speaking in generalizations here and there's room for flexibility in food production and gardens. Some people provide a large amount of food from their gardens that they directly consume. There's no doubt that it's a tremendous opportunity to increase food production in many urbanized countries. A small plot of land measuring only several hundred square feet can provide a large amount of fresh vegetables that (maybe) taste better than the "plastic" stuff, though it's not really plastic it just sometimes tastes that way, that you often find at the grocery store. Commercial vegetable production is based on ease of harvest, stability in transport to the grocery store, and visual appeal once on the shelf. Very seldom is the actual flavor of the item considered in the variety selection for most commercial vegetable operators, although there are some exceptions. Many times, farmers' markets and local producers are a fantastic opportunity to get better tasting produce that has not been shipped across the country, but that's a topic for another day.

An interesting phenomenon, at least to me, is the idea of micro gardens grown by people who live in small apartments or anybody else who has no ground available for a traditional "terrestrial" garden. On their exterior deck they can grow plants in soil-less plant growth media, which is easier than using soils, which might be full of lots of things that may not be good

for plant growth, for their direct consumption. The total amount of production may not be huge, but for that individual they can grow some food in which they can take great pride and delight in consuming. These efforts, under, at times, extremely urban settings, highlight to me the innate desire of humans to be connected in some way to their food and its production. A person could get those alfalfa sprouts or small leafy greens from the local vegetable market more easily than trying to grow them themselves, but yet it is the process and the pride in the success of the process that drives some people, albeit a minority, to endeavor to grow some food on their own.

I used the term the "January garden" earlier. In my experience, the January garden phenomenon is largely caused or inspired by seed catalogs. I received my Burpee seed catalog a few days ago, as I am writing this in late December. Oh! The images of these of fruits and vegetables and flowers! How beautiful!!! How gorgeous! Side note: I find it interesting the sizes of the fruit are so precise, the eggplant is 3.25" x 7.5" at maturity, not 3 x 8" or up to 7 inches. So let's contrast the "January" garden with a more realistic "July" garden. NOTE: Burpee is a registered trademark, and I am not saying anything bad about Burpee seeds. When I have bought them, they performed splendidly. (And no, they did not provide any funding for this book.)

As a person who controls weeds in crops, of course the most important difference is that there are no weeds in the January garden. The Burpee seed catalog only shows perfectly ripe, mature, unblemished fruit, vegetables or flowers. In virtually any garden there are going to be some weeds, and in many situations, they are the central issue that challenges gardeners. Weed seeds can remain dormant in the soil for many years, and when you finally start your garden, the weed seeds will then germinate and grow. The weeds always seem to grow better than the crops, the lawn, or whatever you're trying to grow. If your soil has no weed seeds (not very likely) then the wind, mulch, other seeds, wildlife, neighbors, or something is going to sooner or later introduce some weed seeds into your area. This is a difference between the "January" and the "July" garden.

Small gardens in urban settings may be considered to be "biological islands," meaning they are largely separated from the various living organisms often associated with that general plant or ecosystem. While some species range widely to find your plants, like honey bees which can forage from great distances for nectar and food supplies, other types of insects or other pests really can't travel that far. There are some crawling

types of insects and worms that, unless they're introduced on contaminated plant materials, compost or something like that, really are not going to "find" your garden. Now, if I'm trying to grow roses in my front yard, and there are dozens of other rose plants from a variety of other people in the same subdivision, then there is a pretty good chance that I will have some insects that like to eat roses or diseases that like to infect roses from these other inoculum sources (a repository of disease-causing agents which can hurt plants). That being said, I have roses in my front yard, and I'm pretty much the only person with roses in the entire subdivision, so I have some problems that all roses producers have with diseases, but I simply don't have many of the insects that other rose lovers and growers have to contend with, because those particular insects can't move the mile or two from where the nearest roses are growing to mine. Now that's not true for many species, and the classic example of the species that migrates the greatest distance is the monarch butterfly. I planted a few milkweed plants in my front yard and watched them grow into a pretty good size plant, about 3 feet tall. I didn't really think too much about it, until sometime in the summer when all of a sudden I noticed that all of the leaves were being removed. Upon closer inspection I found some really ugly looking caterpillars that were basically completely eating every single bit of leaf material from the plant. I mean this plant had no leaves at all left on it. It was nothing but stems and it looked very sad. Of course I took a picture of the caterpillar and learned that it was actually a monarch butterfly in its early form. I was excited about having this species in my yard, but I just want to share with you that this excitement was not in the January garden. I say this because the January garden has a certain set of outlooks and expectations, and even though my entire premise is to tell you that the January garden is not as good as the July garden, I share the monarch butterfly story to tell you that sometimes the unexpected surprises in the July garden actually can exceed the expectations, although often unrealistic, of the January garden. Suffice it to say that in the Burpee seed catalog, there are no insects, no insect damage, no blemished fruit, or any of the negatives associated with the insects that often can ravage gardens. By the way, there is a huge disparity of gardeners with respect to using insecticides. Some people let nature run its course, although in a truly natural setting you wouldn't have whatever garden species you just planted there anyway so, that doesn't make a lot of sense if you think about it. I mean, after all, if I wanted a natural system I would just do nothing and let it happen, and then you would have species change over time through the process of succession until you finally get to climax vegetation, where the ecosystem is in long-term balance and where no

inputs are necessary to maintain the climax vegetation. Oftentimes that's not a very aesthetically appealing situation. Anyway, some people who are gardeners believe that no synthetic pesticides should be used on their garden, and they will live with the huge losses from insects. At times it could be a 100% loss of the given vegetable. Others will believe in aggressive interventions using whatever chemical they can get that will kill those blankety-blank insects (genus and species withheld for information to maintain the safety of said insects). There is a continuum of chemical users between the "not on my garden" and "use anything you can get your hands on" ends of the spectrum. Actually, for the home gardeners there is a plethora of available choices oftentimes including effective pheromone traps where I'm just trapping the insect pests before they get into my garden. Side note: the most effective place to put the trap for a given pest is on the edge of your neighbor's property so that you're actually drawing the insects away from your garden. It's not wise to draw all the Japanese beetles right to where your roses are and then hope they go into the trap before they eat your roses. So, you can always tell the experienced gardener because he will offer the opportunity to put the traps on his neighbor's property because he is such a good neighbor. The effects of insects on vegetables is highly variable, and some species such as pumpkins are highly affected by insects that bore inside the stem. Other vegetables such as green beans, really don't have a lot of problems with insects under normal circumstances.

Plant diseases require three factors to be a problem in any situation: a susceptible host, a virulent pathogen, and a suitable environment. The gardener can try to select varieties that have some resistance to the various diseases, although they will have no idea what diseases they possibly could be in the year ahead. A virulent pathogen can be either a bacteria, a fungus, or a virus that can cause a given plant disease, and, depending on the biological isolation of the garden, this may be the best thing going for the gardener. If the source of the inoculum is not already in the garden, there is at least a possibility that even if I grow an heirloom vegetable that is highly susceptible to the disease, and I have the environment that is good for the disease to infect my plant, I still may not get the disease because there's no disease organism to cause it. Plant diseases will grow in a wide variety of environments, but in general terms, if it's really wet for a long period of time or if it's cool for a long period of time, you tend to have more plant diseases. Side note: a plant pathologist would never say it's this simple. They have all kinds of theories and axioms, but in general, when it is wet you have more problems, especially root diseases. Now there are fungicides that are readily available to help prevent some plant

diseases, and people can use them. The real challenge is that for many fungicides to be effective you have to spray them before you get the disease. They are a preventative treatment and not a curative treatment. So, I spray my roses about every seven days to try and stop some rose diseases from knocking all the leaves from my rose plants. I use a product that is formulated so that when it gets rained on, it doesn't get washed off. Still, when it rains frequently I spray more often, which is a real hassle. If you don't spray your roses, and you try to grow hybrid tea roses, you will not be successful. Species of vegetable garden plants have a wide range in their susceptibility to various plant diseases. My asparagus is virtually indestructible from plant diseases. Actually, it's pretty indestructible from about anything once it's established, which is one reason why I grow asparagus because I know the wildlife will not eat it, so they leave it for me (and it's very tasty.) Some common vegetables are prone to very serious diseases; like tomatoes, while other vegetables such as sweet corn have very few plant diseases. Either way the January garden view sees no plant diseases, blemished fruit, necrotic or spotted leaves in their garden.

Depending on where you live, the greatest single challenge to successfully grow plants is whether they receive the appropriate amount of water. Too much water can kill a plant by flooding, or it can cause the roots to degrade and to get infected with various root diseases. Too little water, which can often be the case, can result in the plant processes that need water not effectively occurring. Essentially, all of the reactions inside a plant to take the sun's light energy and turn it into chemical energy in the form of carbohydrates and then into many other chemicals, and then form the whole plant and to eventually make a flower, a fruit, a vegetable happen is in an aqueous or water-based system. So if there is a shortage of water, basically everything stops. Now, depending on the size of your garden, you simply water your garden, no problem. Where I live we get about 60 inches of rainfall every year, and most of it comes in the summer months, so it's pretty nice when you try to grow things here. This is not the case in much of the country, in fact water quantity is a major issue in many parts of the country. If you live in California, you understand that water quantity is a major issue. The people living in the cities along the west coast want lots of water, and they don't understand why the farmers need to flood all these fields in the great Central Valley to "waste" the water. We'll talk more about water in another chapter. Suffice it to say that the January garden has no drought, no floods, and the crops look perfect with respect to water balance.

When I first moved to my suburban home about 15 years ago, there was a backyard which had a really steep hill, but at the bottom, it was pretty level. I decided to put my garden in that lower area. I worked up an area that was 30' x 60', which is not a huge area but is pretty good size. I fenced that in with chicken wire with an electric fence on top, solar-powered I might add. The chicken wire fence was installed so that an animal could not dig underneath it. The total fence was approximately 3 feet high, which I thought would be more than adequate to keep any wildlife from entering my garden. I was wrong. Before that, I had a person with a large tiller working up the soil, every now and then the tiller, although of substantial mass, would jump up in the air! I asked the person what this meant, and he said, "Well, I keep hitting these big rocks." Now, where I'm from originally in Illinois, the soils are deep, fertile, dark and contain no rocks. I have come to learn in my travels around the US that depending upon where you are, there can be a lot of rocks in your soil. I have seen fields in the Northeast United States that appeared to have more rocks in them than soil, and I'm amazed the guys are trying to farm them! But, back to my garden. I tilled the ground up and got a lot of rocks out, added a good amount of inorganic fertilizer, planted some perennials such as Concord grapes and thornless blackberries, and proceeded to "garden" for several years. Although I probably picked a few vegetables from the patch, I would say it was pretty much an abysmal failure. In all my years I never harvested a single bunch of grapes, because some sort of powdery mildew disease, I think it was a mildew disease, would make all the grapes turn into some sort of black wood-like small pellet. This is not a technically correct term, okay, but it was pretty disappointing to have an unbelievably lush beautiful grape vine and get zero grapes from it. Yes, I tried to prune the grapes correctly to allow for more airflow in. Yes, I probably could spray fungicides, but the reality is the grape jelly that I can buy at the store is just about the same if not better than anything I can grow. My wife really doesn't like to make jelly because one summer she ended up with 3rd degree burns on her thumb and hand. She over-filled a jelly jar and got the hot jam on her hand. The thornless blackberries produced huge lovely plants, called brambles, with good-sized fruit on them. Unfortunately, they tasted "just okay" to my children and my wife, and I don't even like blackberries; I have strong, mixed memories of picking blackberries, which were not thornless, as a child on my home farm. A story for another time. Again, my wife did not wish to spend the effort to take these blackberries and make them into jam or jelly, by the way real gardeners know the difference between jam and jelly. The other factor that got to me was that the birds were flying in, the squirrels were

climbing in, the rabbits, deer, and Lord knows what else were jumping in and eating the fruits and vegetables in my July garden. As I got older, it was also more and more difficult to simply walk up and down the hill. I did mention that I have a steep hill in the backyard right? Add all these factors together and I ended up ripping up the fence and sowing tall fescue seed; and I now simply mow it. I have only a small asparagus bed now, up on the top of the hill near my house, since apparently nothing will eat it except humans. The asparagus I now pick is far superior to the green hard stems of wood, hardwood at that I might add, that they call asparagus from the grocery stores. The reality of gardening in urban settings is that wildlife can be a major challenge. To be honest, there are farmers that also struggle mightily with deer that eat their soybeans, and ranchers have struggled with wildlife eating their stock for generations, so in that way there are similarities with the urban and rural farmers. Now, the stores sell mechanical control measures, such as motion activated water blasters. These may work. The stores also sell fake predators, such as hawks or coyotes, etc... I realize most wildlife are not that smart, but after a few weeks of a thing not moving, I think the critters might figure it out that the thing painted like a predator is not really a threat... The January garden does not mention or see any wildlife damage.

Year-round schools have changed Americans' lives in many ways, depending on the level of adoption of this change in your education system. Historically, schools were closed in the summer months, ostensibly to allow the children to work on the farm, tending the fields, and providing free labor to their parents. I will not even begin to comment on the changes in parenting and how the lack of agricultural involvement has changed the work ethic of our society today. That would be a topic for another book. But with respect to gardening, years ago you would basically plant your garden about the time school got out, and most of the harvesting would be done prior to school beginning again in the fall. Such is not the case anymore. Additionally, vacations used to happen primarily in the summer months when the "kids were out of school." This would mean that the garden would be untended for a period of time ranging from a week to two weeks or so. This would mean that any kind of maintenance, weeding, watering or harvesting, would not be happening in the absence of the gardener. Of course, the January garden does not show any of these absences or any of the okra that wasn't exactly the right size and in fact is about 2 feet long and could be used in construction of housing because it's so tough. The January garden does not show the tomatoes that have rotted on the vine because nobody was there to pick them, and now they are a slimy, rotten mess. When the gardener returns, it

will take a day to clean up all that mess and throw a bunch of stuff away, no real problem. Probably, the compost bin is pretty close to the garden anyway. I know this can be true, since when I returned home from a summer holiday, this is what I had to do each time.

To get a perfectly-formed, aesthetically-pleasing mature fruit or vegetable requires a dance of many inter-playing factors. One aspect that is never really focused upon is mineral nutrition of plants. Plants extract nutrients from the soil. They store these largely in the fruits and vegetables because that is where the seeds are, and that is where the plant is trying to get the best chance of survival so they put the most nutrients in the fruit or vegetable. Then, we humans eat that fruit or vegetable because it contains the same nutrients we need to live.

Fertilizers are a big part of successful gardening, just as they are an essential part of farming. We will talk about fertilizers and especially nitrogen, phosphorus, and potassium in another chapter. However, and you are probably getting tired of hearing this, so I believe this is the last time I'll say this phrase, the January garden does not have any nutritional deficiencies in the plants, and the plants/fruit are not withered because they do not have enough of a certain nutrient.

The January garden always produces perfect fruit, vegetables, flowers, lawn, tree, or whatever you are trying to grow, that is the way it is. There is nothing wrong with that, and this annual renewal of optimism as we come out of the winter season is an overwhelmingly positive attribute of the human species. Even though the trees have lost all their leaves, and the grass doesn't look so good in this cold, and it is raining, snowing or whatever, we can look at that Burpee seed catalog, and we can dream, and we can enjoy that time and the harvest of the days to come. I am not surprised that the Bible begins with the story about a garden and how a person(s) tended the garden. I guess as humans we kind of messed up and perhaps were not as good a gardener as we could've been.

The idea I have shared with you about a January garden could also be extrapolated to many metaphors in life. A couple of them which I'll just discuss very briefly include:

the first day of college for you or your child,

the day you got married,

your first day on your dream job,

the day you get the car/boat/furniture/etc. item you have always wanted.

On the first day of college, actually before classes start, when you move into the dorm room, you have not had classes that you needed for graduation get cancelled or that you cannot get because of scheduling conflicts. You have not gotten drunk and missed so many classes that you may be failing out of school. You have not been denied access to that social organization, the fraternity or sorority that you really wanted to get into. You did not realize how expensive the books were, the tuition was, the course fees, etc. You start to wonder, "Do I really want to be a 'fill in blank here' for the rest of my life?", and all those other very real questions that college students ask themselves. Some of the saddest events I have witnessed are when a college student ends his or her life due to depression issues. A young life ended is the worst July garden outcome of them all.

Very few, if any, men and women walking down the wedding aisle are thinking that 50% or so (I estimated this number) of marriages end in divorce. They do not foresee the money problems, the differences in expectations of what their in-laws have for them, the grand decisions about their two lives which were completely separate but now are going to supposedly be in harmony as one, different views on sex, different ideas about having children and if you have children, how to parent them, what religion will you be, or if you will even have any religion, and so many other questions. A friend of my wife's family was married five times, and my mother-in-law on the fifth time asked the man, "Why do you even bother getting married?" I read reports about how some couples are making a conscious decision to live together but not have a wedding. I find that to be very sad. Getting married, at least for me, has been one of the few parallels with the January garden. The wedding was pretty good, but the life I have lived with the woman I married has been better than anything I could have imagined. My July garden has turned out better than my January garden. Side Note: this is not a book about marriage. I hope the same for you.

Maybe you've always wanted to have that specific dream job, and you thought that everything was going to be great once you got that job. I am sorry to inform you that if your self-worth comes from only what you do in your occupation, you will probably suffer from the January garden view. Your boss may not be as nice as she or he appeared in the interview, the travel for the first six months was pretty exciting, but after a while, it got to be a grind. Yes, you make a lot of money, but you never have any

time to enjoy life. Many other things take away from the dream job, and sometimes it's not a happy dream.

Some people believe if they could just get that house, that sports car, that Bass-tracker boat, super-duper ski boat, or whatever that material thing is, then they would be happy. Well, I've got a lot of things, and they are nice to have. I am not sure who said it first, but I will attribute this quote to Mae West, "I've been rich and I've been poor, and rich is better." I grew up in an absolutely impoverished rural situation as the sixth of seven children. I never knew how poor we were until I went away to college. Now, there are lots of people who are richer than I. I'm not going to say that if I was really poor, it wouldn't bother me, but I see far too many people who spend their entire life working too hard to make money. The quote I once heard was, "We spend all our life and our health making wealth, and at the end of our life, we spend all our wealth on our health." For many people, the allure of the dream was better than the reality and such is life.

I close this chapter in the story about the contrasting of the January versus the July garden with perhaps one of the saddest outcomes of them all: the seed never gets planted. Now in a gardening situation this may be due to several reasons. It rains too much, the gardener gets too busy, or many other possible scenarios. A biological and theological concept of relevance to this topic is that "you harvest what you sow. One that sows much can expect to harvest much, etc." A personal story which may help illustrate this idea involves my personal desire to learn the German language. My three children and my wife all speak German. So I, with the very German last name of Mueller, am the only one in the family who speaks no German. Side note: I have no intention of doing those DNA test to see if I'm actually 100% German, since the probability of me actually being 100% German is pretty low. Anyway, I talked for years about taking a German class at the university. After years of delay, I finally signed up for the class. To make a long story short, I did not succeed. Even with my children to tutor me, I simply could not get the vocabulary to stick in my head. I remember as a young man I would rapidly learn new ideas and concepts, and I could memorize long lists of things. Such is not the case anymore, at least for me. I dropped the class to allow another student the seat in the class. I was apprehensive about how my children would respond to my quitting, but I must say I was pleasantly surprised when they were wholeheartedly supportive. The generalized sentiment was, "You know dad, you have talked about this German class for a long time, and at least now you tried it. We are proud of you for attempting it." So to

use my gardening metaphor with respect to this class, I planted the seeds and at least attempted it. How sad the story when a person has seeds to plant but never does so. For me it was learning German, but for you it might be learning to play music, taking a trip somewhere, learning a new craft or hobby, or so many other possibilities. I guess it is better to have tried and failed than to have never tried at all.

Farmers fully understand the fact that if they don't plant something, they will not have a crop to harvest. Commercial farmers live in a reality where many factors affect their incomes. Some are in their control, and some are outside of their control. I have discussed these in other chapters, so I won't go through them again. But people think they understand farming and farmers, thinking, "How hard can it be?"

But in reality they have no idea, and that is why I wrote this book.

Thanks for reading. Yes, I know I have used that phrase before, but I'm sincere in my use of it.

CHAPTER FIVE

FARMING IS NOT "BIG GARDENING"

Most people have some understanding or at least an idea about a garden full of vegetables, maybe a patch of flowers around their house or maybe some landscaping/lawn surrounding their apartment. Farming in the United States is not gardening.

People in the United States are essentially completely separated from their food source. They, for the most part, have no idea where their food comes from, how it is grown, processed, transported, stored, distributed or marketed and finally how it ends up on their table at home (or at their restaurant or fast food restaurant of choice).

Our national government policy has been one that favored abundant and low-cost food, and these policies have been in force for many years. While the food production complex is quite diverse, I will focus on the broad acre production of energy and protein crops. Farmers in the United States (as opposed to ranchers that have livestock) grow four major food crops (by the amount of farm land each crop occupies): corn, wheat, and rice for energy and soybeans as a protein and oil source.

To start, I'd like to define a few terms including acres and bushels. I know, definitions are the worst! Bear with me, I'll try and make it as quick and painless as possible. (Sort of like a dentist). An acre of farmland is a unit for measuring land area which dates from the Middle Ages. An acre is the amount of land that one man and one ox could plow in one day and equals 43,560 ft^2. As a point of reference an American football field is 1.32 acres, roughly about 1 acre. Once a given unit of measurement is applied to a piece of farmland it is surprising how persistent that unit of measure is in staying with that farmland. A story to illustrate this idea goes like this: Israeli farmers measure their fields in a unit called a "duama" which is a remnant from the Ottoman Empire (not exactly the most friendly group toward the Jews). By the way, one duama = 0.25 acres. I have no idea what the basis for this term for this unit of land area is.

Crops at the farm gate (where the farmer delivers them to sell them) are either measured in bushels or hundred pound weights. It's kind of bizarre because it's technically a unit of volume, but they measure it by weight or mass when the farmer sells the crop. (I realize that physics teachers are going ballistic because weight and mass are not the same thing, but it's how much something weighs, okay?). A bushel is a measurement capacity equal to 64 US pints, and it's used for dry goods. Different crops have different densities and so have different pounds per bushel. Wheat is 60 pounds per bushel, corn is 56 pounds per bushel, and soybean is 60 pounds per bushel (made up roughly of 11 pounds of oil, 44 pounds of protein meal, and 3 pounds of miscellaneous which they call hulls). Rice is not measured in bushels: instead it's measured in 100 pound units (not sure why that is, but that's how they do it). Cotton (not discussed here, since few people eat cotton, although it is considered a "food crop") is measured in pounds per acre as seed cotton, then processed (ginned) to yield pounds of lint per acre, and a common unit is 500 pounds per bale. Thus, a cotton crop with 1500 pounds of lint per acre would be described as "three bale cotton" (by the way this is an exceptionally good yield). Speaking of yields, the grain yield of each of the other crops varies widely, but good yields of the various crops for corn is 200 bushels per acre, soybean is 60 bushels per acre, and wheat is highly variable depending on how much input is put into the crop, so it could be anywhere from 40 to 120 bushels per acre.

I realize I'm not discussing in this book many important crops routinely produced in the United States including peanuts, tomatoes, oranges, lemons, sugar (how can you NOT cover sugar!, okay, I'll cover sugar later,) and of course all the other vegetables and fruits that we eat. I am NOT saying they are not important, but I want to focus on the major agricultural crops. If it makes you feel better, I will tell some stories about these "minor crops" along the way.

The ancient relative of our modem corn is normally considered to be teosinte and is normally considered to be native to Mexico or Central America. Grain yields of teosinte are very low (not sure, but I would guess maybe 10 bushels per acre). The early American farmers selected different plants over the years that resulted in our current day *Zea mays* plant looking very different from teosinte. By the way, the rest of the world calls *Zea mays* not corn, but maize (sort of makes sense to me, but then we call football soccer.). Corn is grown on approximately 90 million acres each year in the United States and basically has four major uses. The most common is for animal feed, followed by ethanol for fuel in our vehicles,

various industrial uses, and for direct consumption.

A common question is, "Why do American farmers grow so much corn each year?" (We've now reached the FAQ section, I see). The short answer is that it gives them the best opportunity to make as much money as possible. There are many reasons for this, but it is mainly due to a combination of several factors, including good (actually fantastic) soils and a suitable climate over a large geographic area which is collectively called the US "corn belt." While open to interpretation, it generally goes from Ohio to Nebraska and from Missouri to North Dakota and is dominated by the "I" states of Iowa, Illinois, and Indiana. Corn yields have steadily increased over the last 100 years due to a convergence of improving technologies. Hybrid seed corn, the use of abundant and cheap inorganic fertilizer, the essentially complete removal of all pests (weeds, insects, and disease), and excellent equipment to plant and harvest these crops have all combined to produce abundant harvests.

Production of broad acre crops is totally mechanized and partially automated. A farmer may check his crops occasionally (usually from his pickup truck cab), but all the actual tasks are done by machines, which are becoming more autonomous each year. Tractors now come standard with "auto steer" and "auto-guidance" based on GPS navigation systems. Equipment to apply pesticides to fields (referred to as sprayers) routinely have large "booms" that are greater than 100 feet wide when in the operating position. These spray booms can be retracted into a much smaller width for transport between fields. Huge machines to collect the grain at harvest time are called combines, since they *combine* the two separate tasks of *gathering* the crop into the machine and *threshing* (separating and cleaning the grain away from the chaff and other plant residues) into a single machine. The cost for this modern equipment is high. A modern tractor can easily cost $200,000 and the combine can cost more than $350,000. But the efficiency and productivity of the modern US farmer is astounding. If an operation can plant hundreds of acres in a single day, then at the end of the season it can also harvest the crop very rapidly. Given the high cost of labor, the equipment has gotten larger and larger, and the economies of scale (spreading fixed costs over more acres) have encouraged large farms to spread over thousands of acres.

Current corn hybrids yield far greater amounts of grain than teosinte (the ancestral relative plant from which we have bred our current corn plants). Soybeans, wheat, and rice have also seen increases in their yields, though perhaps not to the same extreme extent as corn. The other crops are also

more closely related to their genetic ancestors from which they were selected. Much of the same equipment and technologies is used for all the agronomic crops and many times the crops are grown in rotation with each other. While I'm not here to bore you with lots of details, I did want to provide some numbers as far as what a typical farmer might be experiencing in his/her operation. To that end I have produced the table below, which is just an approximation of some numbers so you can get an understanding of or at least a feel for some of the numbers of farming.

So, what is the selling price a farmer gets for the crops?

It is highly variable, but corn has ranged from $2 to $8 per bushel (usually about $3.50), soybeans ranged from $5 to $16 (normally around $9), and wheat ranges from $3 to $8 (with normal about $5). The truth is, the price changes every day. Commodity markets allow for rapid changes in crop prices that are traded on global considerations. Bad weather in Ukraine and Russia can make wheat prices go up here. A drought in Argentina affects soybean and corn prices. Historically, the most important agricultural commodity exchange was in Chicago, at the Chicago Board of Trade. It still is an important factor in farmers' lives today.

Farmers operate complex business enterprises with huge capital costs to start up and then to operate their modem farms. To be sure, there are also a large number of "part-time" farmers that "farm" on weekends and at night. In some ways they are the same as full-time farmers, but in other ways very different. My oldest brother is one such part-time farmer.

The capital inputs to start a full-time farming operation are high at approximately $1 to $2 million. For this reason, the majority of young farmers are the sons or daughters of established farmers. The asset base (land and equipment) is often passed from generation to generation. Think of the job you do, if you have a job. Are you in this profession solely or mainly because your parents did the same thing? Of course, sometimes the answer is yes. For example, a person's dad was a doctor (medical) so that person chooses to be that profession, too. However, most people do not inherit multimillion dollar estates from their parents, I wish I had! There's nothing wrong with the fact that most people do not end up in the same "family business," that is just how it is.

		corn			Soybean			Wheat	
Total Item per acre per year	Low	average	High	Low	Average	High	Low	Average	High
Yield in Bushels	100	180	300	35	50	80	30	50	65-120
Seed cost	50	70	100	15	25	55	10	15	30
Fertilizer cost	50	110	200	0	20	40	20	30	70
Equipment Inventory, per farm		Millions			Millions			750 K	
Land cost, rental	100	250	450	100	250	450	50	120	200
Pesticides	35	50	80	70	90	130	20	40	60-150
Total cost per are per year	335	660	1130	220	435	730	130	255	425 to 570

Another aspect of long-term land ownership or farming a parcel of land is stewardship. Very seldom will a farmer purposely degrade the soil in their fields. Yes, it sometimes happens, but in my experience, this is rare. Most farmers want to leave the land, farm, and machinery in as good or better condition than when they started. I consider most farmers to be extreme environmentalists and conservationists with respect to soil preservation. For them, it is an investment as well as an important part of their heritage.

Farming in the United States is largely unregulated. In most "broad acre" situations, a farmer can choose what crops to plant (albeit soil, weather, available markets, and to some extent government programs dictate their decisions). I will discuss organic farming certification in a later chapter, and those producers do have greater restrictions.

For those humans who eat meat, which is some of you, I want to offer a view on large-scale livestock farming. NOTE: I am not an expert on livestock because I made the deliberate decision to NOT pursue a career in animal science. (BTW, I think any technical discipline with the word "science" in the title may not be overly scientific. Would you think more of an entomologist or a "bug scientist?" Soil pedologist or Dirt Doctor? As a "weed" scientist... Well, I get no shortage of marijuana jokes or comments. Oops. Better get back to livestock). Livestock need food, water, and shelter EVERY DAY, often multiple times each day. Modern dairy cows (the black and white ones on Chick-fil-A commercials are of the Holstein breed or variety, an enormous breed of cow) are milked two and sometimes three times every day. The scale of modern livestock farms is hard to capture in words, as is the smell.

Picture, if you will, a factory to make pork. On one "end" (this is quite a mental image!) you add small piglets you bought from somebody that operates a "farrowing" operation, plus feed and water... You feed the pigs, and on the other end of the barn the "finished" pigs come out ready to be sold. Often these barns have slots in the concrete floor so the liquid and solid waste go directly into a pit under the building. This liquid manure is mixed up and is a valuable fertilizer to help crops grow.

I find liquid hog manure particularly pungent. On the farm where I grew up, one of our neighbors lived about a mile away from our house. He farmed a field just in front of our house. Guess where he would spread the liquid manure? Yes, in front of our house. I remember as a youth that my dad told me this story about pigs, which historically have been profitable and sometimes were called "mortgage lifters." My dad's story goes like

this, "when you spread the liquid hog manure on a field, and they are your hogs that smells like money; if they are not your hogs it smells like shit!"

By the way, the hogs are completely content to eat, sleep, and gain weight. The pig farmer desires as little stress and disease for them as possible. Years ago, essentially all pork producers routinely added antibiotics to the rations that they would feed their animals. This is less common now, although I'm not an expert on hog feed ration components, but I know hog manure stinks.

Manure is actually a major dilemma for livestock producers for two reasons. Firstly, yes it is full of essential nutrients and helps crops grow, but too much can cause very real environmental problems. These confined animal feeding operations (CAF●) must have a manure management plan (M●MP) that meets local regulations. Seriously, I'm not making this up (I could not make this up). The second problem is the money versus shit viewed dichotomy, which I mentioned before. The farmer smells money, but the city guy (aka slicker) who bought the small farmstead (his or her little piece of heaven in the country) and has four horses, well, they smell shit. This could be a real problem for farmers when a subdivision springs up next to them. ●f course, the farm was there first, but 15● homeowners have more votes than a family farm of four or so. The urbanization of farmland is a challenge in some areas.

I realize some of you may have held the idyllic view of farmers only working the land to produce lovely vegetables for you to enjoy. Truth is, there are far more acres of corn, soybeans, wheat, and cotton than there are of vegetables. Farmers in the United States are immensely productive but margins and sometimes profits are good some years, lean in others, and you just try to break even in others. Weather (here and in Brazil or China), government policies (our own and other governments), and many other factors outside the farmers' control greatly affect his/her success in any given year.

At heart, farmers are eternal optimists. Even when the "sharpened pencil" says to not plant a crop, they almost always will. The weather will be good and the commodity prices will improve. I have supreme respect and admiration for the United States' farmers.

They feed us all.

CHAPTER SIX

THE ORGANIC MYTH

This exact title was used in a Bloomberg article that was first published several years ago. I wanted to read it, but I chose not to spend $120 to read it online. It is a pity, it might be a good article.

The general use of the term for food that is "organic" is generally attributed to Englishman Lord Northbourne in about 1939. He coined the term "organic farming" in his book *Look to the Land*, from his concept of "the farm as organism" to describe a holistic, ecologically balanced approach to farming. He contrasted this approach to what he called *chemical farming* which relied on "imported fertility" and thus "cannot be self-sufficient nor an organic whole." For those that are not aware of the term, this differs from the scientific use of the term "organic" which refers to a class of molecules that contain carbon, especially those involved in the chemistry of life.

To produce and sell food under organic systems, a farm must be certified, which is a process for verification of organic food and other organic agricultural products. Any business directly involved in organic food production or processing can be certified, including seed suppliers, farmers, and food processors. Requirements may vary slightly from country to country and generally involve a set of production standards for growing, storage, processing, packaging, and shipping that include the avoidance of:

synthetic chemical inputs (such as fertilizers, pesticides, antibiotics, food additives, etc.),

genetically modified organisms (GMOs),

irradiation,

sewage sludge application to fields.

Farmland must be free from chemicals for a number of years, often three

or more is required, prior to organic certification. The owner must keep detailed written production and sales records to allow for an audit trail. Strict physical separation of organic products must be maintained from noncertified products, and the producers and retailers must agree to undergo periodic on-site inspections. As far as I can tell, all that the inspections involve is making sure certain things do not happen in an organic operation, there's really no inherent interest in seeing if the food or that the product is actually healthy and safe. Many people who buy organic foods probably do so because they believe the systems are more "natural" and "sustainable," although another reason cited is the wish to avoid any pesticide residues in their food. In times of food shortages, for example during times of war, there is little talk of sustainable practices. Those involved in the struggle are in a struggle for survival.

As a human's basic needs are fully met and satisfied, we can begin to get more choosey and selective about our foods. A few quotes about food would include:

"Hunger is the best spice to improve the taste of food."

"●nly the man who was truly thirsty will know the refreshment of a cold water spring."

So, I have come to a point in my life where food (or lack thereof) is no longer a motivating factor to me. I can choose from a plethora of different selections for my breakfast, etc. How and why do some consumers decide to buy organic foods?

Perhaps they have been made ill and sick by some foods? After all, they have bad, toxic things in them, don't they?

To be sure, people do get food poisoning. I am told that frequently what people call a "stomach flu" may alternatively be a mild case of food poisoning (think potato salad at a family picnic on a warm summer day). There are horrendous and tragic examples of people being sickened and killed by food contamination, but these are normally caused by microbiological organisms such as E. coli, listeria, salmonella, and others. I know of no one who has reported a negative effect from food based on "non-organic methods."

You know lots of people, right? Can any of them tell you a story about how they ate some_____ food item and got sick from the pesticide residues that it contained?

However some of the food poisoning events reported to the Center for Disease Control & Prevention (CDC) and the FDA involve organic produce. Now, isn't that interesting? Side note: not sure why CDC tracks food poisoning, but someone needs to do it I guess.

The truth is, crop protection chemicals, a.k.a. pesticides, are tested on lots of things (test subjects of various species) to make sure they are safe. But, many folks do not believe scientists (I know, I don't believe lots of scientists either). But organic food being "safer" does not pass the common sense/smells bad test to me.

Not everything you read on the Internet, even at a NG● website, is true.

●kay, but organic food has better nutritional value, right?

Sorry, but no.

The main differences between organic foods and nonorganic foods are the quality and the price. In the absence of chemicals (yes, I know, I should not use this nasty word), there may be more imperfections due to diseases and insects on the organic food. The organic crop yields will be reduced due to the imperfect weed control, lower fertility, and so forth. But, you can easily tell the difference between organic produce and other produce just by looking at the price tags. ●rganic products cost more. I'm paying more money for a lower quality product. This makes no sense. But, why do you do it? I will now explain.

How humans make decisions is a fascinating topic, and it is one I am not competent to discuss or explain. However, a lack of data, understanding or knowledge has never stopped me before (does this remind you of anyone you know?). So offwe go!

In the simplest terms, when a human is confronted with a threat, there are three choices: fight, flight, or freeze. (My guess is that you've heard about this idea somewhere in your past). We take no action (freeze). We attack the danger (fight) or we flee from it (flight). How does this reaction relate to food choices?

You go to the supermarket to buy food for yourself and your family. Let's pretend you have two small children. You have made a list, and then you come to buy an item on the list. You have several choices of the product, and some have labels on them, such as "contains no genetically modified organisms." So, you think, what does this mean? Being entirely ignorant

of your food production system, you are now fearful of this "GM●" thingy. This GM● may be harmful to my child. So, I will be a "good" parent and buy my child "only the best" because nothing is too good for my child. You perceived a threat, GM● thingy, and you decided to flee from it by not buying it.

Did you take the time to compare the cost of the conventional and the organic produce? Did you take the time to compare the quality of the conventional and organic produce? No, you really did not. By the way, food distributors play this game all the time. Have you heard the following words or phrases:

All-natural

Gluten-free

Non-GM●

Carbon free (or Carbon neutral, or low carbon)

Locally grown

Sustainably farmed

Eco Friendly

Many consumers are so ignorant, that it is funny. Gluten is a protein in wheat, so to have gluten-free orange juice; well, this is just silly! ●.J. doesn't contain wheat, therefore it can't have gluten wheat protein. As another example, there are no transgenic oats varieties, since it is too small a market to justify the cost of research and development, so Cheerios contains no GM●. Who cares? Well, apparently somebody does, or they would not put it on the label.

The greatest fear we have as humans is the fear of the unknown. We do not understand something, so it must be feared and thus avoided. I will now tell you the truth about organic crop production to perhaps reduce your fears.

When people buy organic food, what I think they most desire is food with no residues of pesticides. People are largely ignorant of pesticides, but highly desire a chemical in a pill to give their child when they have an ear infection, see Chapter 14 on antibiotics. Most consumers are fearful of pesticide residues, after all didn't Rachel Carson prove that in her book

Silent Spring?

If you believe organic crops are grown without chemicals, you are wrong. The organic folks just pick and choose some criteria to allow the use of a particular item for their organic crops. If you mined it from the earth; it is okay to use it. If it comes from a fermentation process; it is okay to use it. It comes out the back end of livestock; it is okay to use it. These are actual, real regulations and stipulations. So, let's consider the major aspects of crop production inputs: seeds, fertilizer, insects, disease, and weeds.

●bviously, organic farmers cannot use transgenic (a.k.a. GM●) varieties. You probably believe they use heirloom varieties that taste better, have higher yields, have natural resistance to every possible stress, etc. To be sure, heirloom varieties often taste better because large scale farmers, maybe in the central valley of California, often pick their produce early and let it ripen enroute to market, think like a banana goes from green to yellow (and then to black). A firmer tomato can be harvested by machine or more rapidly by hand, than a fully mature, hand-picked one. Modern varieties emphasize yield and ease of harvest/shipping/shelf-life for fruits and vegetables and then everything else, such as flavor. A good example of this is strawberries. I grow an heirloom variety of strawberries in my garden called Earliglow. This heirloom variety actually tastes like strawberries. Many times what you buy from the store, probably produced in Southern California, look beautiful and are large in size and ship beautifully. The only problem is they taste like plastic, and I personally do not like the taste of plastic. Nothing against the farmers who grow the strawberries in California, they are responding to what the average consumer wants; aesthetically appealing fruits of large-size with uniform color and texture. My guess is that if the supermarket had taste comparisons of the different varieties of strawberries at the point-of-sale then people will probably choose something besides what is grown currently in California. However, that doesn't make the supermarket more money. By the way, a conventional farmer can use all the same heirloom varieties with no restrictions. There are times when a conventional farmer grows heirloom varieties because they often taste better. There really is no advantage to the organic farmer on variety selection; since he can seed only a limited number of varieties while a conventional farmer can use any variety that he wants, including any transgenic lines that may be better from an agronomic standpoint.

As a portion of a plant is removed from that area of the earth, there are minerals or nutrient that are taken from the soil or ground. Fertilizer is the

means of replacing the minerals that the farmer removed from the soil by harvesting his crop. One advantage of organic farms is that their yields are usually lower, so they remove less nutrition from the soil, so they actually need less fertilizer. Didn't think of that one, did you? Adding nutrients that are "legal" in an organic production system is not easy. If your organic farm is adjacent to a large organic livestock barn, you might be okay. The purchase of organic fertilizer is expensive. But, if it comes from the ground, it is okay. I can buy "certified for organic use" nitrate that is mined in Chile and shipped up here to the United States and "legally" use it on my organic farm. But, the ***identical*** nitrate that is made inside a chemical plant is not allowable. It is biologically impossible for any plant to discriminate between mined nitrate and chemically produced nitrate. The process doesn't make any sense to me either. For full disclosure, the mined substance is sodium nitrate, while the dry chemical products include urea and ammonium nitrate. I also believe that use of mined Chilean nitrate will likely soon be disallowed for organic producers.

I was on this organic farm field tour in Norway in 2007. The farmer, a nice guy and very knowledgeable, shared his opinion that the only way he can make money with organic farming is to have his own livestock, graze those organic livestock on some of his land, collect his own organic fertilizer, and use that on his cash crops. This approach seems reasonable to me, but not many organic, or nonorganic farmers for that matter, want the hassle of rearing livestock.

Fast forward to 2009, I was at a meeting in Kobe, Japan. Yes, I go to meetings in many wonderful, faraway places. (Side note: if you like beef, the best tasting beef I have ever had was in Kobe. They call it "Kobe" beef – not original, and due to the sort of crazy currency conversion it cost me either $50 or $500 per pound. It was the best steak ever!) Anyway, I'm at this meeting eating lunch, and this person in our group works for DowAgro Sciences, now a part of a company called Corteva. We were talking about insect control in organic vegetable production, and he told the group that one of his company's insecticides was approved for use on organics. I laughed, but it was true! The chemical's name is spinosad, and it's sold under the trade name of Tracer in cotton and is produced using a "non-chemical synthesis" route. It is a fermentation product, thus it is not chemically made, so whammo! It can be used on organics. By the way, it is a powerful broad-spectrum insecticide that provides excellent control of insects.

Now, do your organic fruits and vegetables sound less "pesticide free"? ●f course, your organic farmer may not use any chemicals, this is just an example, but maybe he does. It is completely legal for him to do so. The bottom line is that organic does not equal chemical-use free.

Plant disease organisms generally do not infect humans. I can think of none that do, although there are some, and they are rare. A concept for all diseases to occur is that three things to happen, often called the disease triangle:

a susceptible host plant,

a virulent pathogen, and

a suitable environment to allow the disease to prosper.

Let us consider each of these in organic production.

Non-GM● varieties may or may not have resistance to the many plant diseases that sporadically affect crops. It is safe to say that some heirloom varieties of some crops were discontinued due to a sensitivity to a given pathogen. Still, some others have good natural resistance to some or most plant diseases.

A fungus or disease causing organism may or may not be present in a given field situation. There is little a farmer of any type can do about the inoculum, the spores or fungi parts that can cause plant diseases, that are present in their fields. It is possible with more diverse crop rotations to potentially reduce the amount of disease problems, and both organic and conventional farmers often use crop rotation to reduce disease pressure in their fields.

The third factor is a suitable environment for the disease to develop in this crop. This often means how wet it is or how much rain falls on the field. Rain for many days sometimes means more plant disease. If the first two parameters are met, a non-organic farmer can spray highly effective, safe-to-human fungicides to prevent or control plant diseases. Typical use rates are less than half a pound of active ingredient per acre. ●rganic farmers either live with or tolerate the plant disease, but some may choose to use the "legal, safer" organic alternative of "flowers of sulfur" (mined, of course and not chemically produced). The trouble is, the use rate of this organic sulfur treatment is 5● or more pounds per acre! This is 1●● times the nonorganic treatment, and the sulfur is not selective and often not as

effective. Organic producers often have more plant diseases, use large amounts of chemicals per acre, and often the produce still looks bad because of various plant diseases. Of course, my guess is that the disease-damaged produce can be made into juice.

Being a person that works on the control of weeds I must admit to an inherent bias about the topic of weeds in crops. That being said, weeds are often the most difficult-to-control pest for organic farmers. The organic farmers have some pretty good insecticides and can manage plant diseases with crop rotation or perhaps some inherent disease tolerance, but weeds are a major problem. Either the weeds reduce yields or the farmer spends much time/effort to control them. With no effective herbicides available, the organic farmer must more effectively utilize other weed management strategies, including cover crops, mechanical tilling prior to planting, and using machines to kill weeds between the rows after the crop emerges. Sometimes hand weeding is used, but farming is not big gardening. How about you (yes, I mean you, dear reader) try to hand weed half an acre of cucumbers. It is almost impossible! Imagine if you tried to remove, by hand, the weeds from your yard or one of your friend's yard etc. How long would it take you? The organic farmers that I have visited (I have only been to visit a few) fall into two broad categories: A. weeds all over the place or B. no weeds at all.

While most fall into category A, the category B farms are joys to behold. What these farmers are doing is "depleting the weed seed bank" so they have fewer and fewer weeds each year. It can work, but it is difficult to accomplish. Unfortunately, farms are "open systems," so new weed seeds can be brought in by wildlife, manure from organic livestock, equipment, or humans (think about you-pick operations). Just driving our cars onto the farm and going to the field can bring in weed seeds (and pathogens, too). Category B is the sound biological approach toward weed control in organic production systems.

My guess is that most "food buyers" believe that the use of organic farming methods somehow magically enhances the organic farmer's soil. Well, I am sorry, that is NOT true because a conventional farmer can use all the same techniques an organic farmer can use. Cover crops and manure applied to fields can increase soil organic matter. Crop rotation (growing different crops in a field over the different years) to break disease and insect cycles is a good idea. For that matter, any good production practice that organic farmers can use, so can any conventional farmer. But, it does not go the other way.

A conventional farmer can use a no-tillage system, in which mechanical disturbance of the soil is essentially eliminated or stopped. This process results in better soil qualities, including better water infiltration and more earth worms, and who does not like more earth worms? But in order to stop all soil tillage, the farmer must use herbicides to kill the weeds or the cover crop that is there and then usually use more herbicides after the crop emerges to kill the weeds later, often using a transgenic crop variety. Now, the avoidance of tillage is a huge positive to increasing soil "goodness" and to reduce soil "badness," such as erosion into rivers and lakes. Yes, these herbicides kill the plants, but there are still lots of worms and everything else in the soil.

Because the organic guy cannot use herbicides it means he must till the ground several times, to kill the weeds/cover crop present and prepare the soil for planting seeds. Many conventional farmers still till their fields prior to planting, as they believe tillage allows the soil to warm up more rapidly in the spring and so they can plant earlier. Besides this early tillage, the organic farmer also needs to control weeds while his crop is growing. This task is difficult for him, since he must till the soil again. In contrast, the conventional farmer can spray his fields and kill all the weeds and not his crop, then not have as much yield reduction and thus make more money.

There is no magic sauce in organic-farming soils. The pesticides used in conventional farming do not sterilize the soil and in fact soil microorganism populations are diverse and plentiful and hard to kill. Now, some farmers of specialty crops use soil fumigants that are applied underneath plastic layers called mulch. This particular application has the exact aim of sterilizing the soil. But these applications are not common in broad acre farm. Did I mention plastic mulch?

I was at a meeting, to be honest I don't remember which one; I guess I should pick some exotic locale, since how would you know I'm lying? I was listening to a talk about organic vegetable production. This speaker is talking about using "plastic mulch" in her organic production system. (Think of a heavy-duty plastic kitchen bag, but on a roll about 1 mile long and 4 feet wide). I turned to the person next to me and asked, "Can you really use black plastic mulch in organic production"? The person says "Sure, why not?" So I'm going to ask you, *dear reader,* is there anything more synthetically chemically made than black plastic? And *that* can be used on organic farms? Are you kidding? Well, the organic folks say "there are some production systems not feasible without black plastic

mulch." Oh, really? Now, to be sure, conventional growers of many vegetable and small fruit crops extensively use plastic mulches and fumigants within their production systems, so there is a similarity.

And at the end of the growing season, where will the plastic mulch, now in shreds because it disintegrated over the growing season, end up? Can this be composted and used next year as a soil amendment? I don't know why not, since you used it last year. This does not sound "sustainable" to me.

Oops, now I've gone and done it. I've used the "S" word. People who buy organic food truly believe organic farms are sustainable. Okay, let's see.

I was at a meeting (again, same story as last time) and the topic was straw. Rice straw to be precise. According to the speaker, the farmers from a certain area (the Mekong Delta in Vietnam, I think. Well, it might be Thailand. Yes, it was in Thailand, I think) had the practice each year of burning the rice straw in the field after the rice crop is harvested. The greatly reduced straw amount allowed for a more rapid re-cropping, the rice straw used up much of the available nitrogen in the field if it was allowed to slowly degrade, and thus would slow the growth of newly planted rice plants. A person from the audience asked a good question (well, I thought it was a good one). Was this practice good for the soil, and was it sustainable? The speaker said that he thought soil affects were minimal, and he didn't know if it was sustainable, but the farmers in this area have been doing the same thing for about 1000 years. I believe his exact words were "Straw burning is only sustainable if 1000 years is long enough to decide." What many of us "trained scientists" sort of thought was non-sustainable/bad (burning in this instance) was in fact completely sustainable. From a carbon/nitrogen balance, what do you think happens to the rice straw in a rice paddy? Microbes attack the straw and convert it into carbon dioxide or maybe methane. Minerals that do not burn are converted into microbial biomass and returned to the soil. What happens when you burn the straw with fire? The straw is converted to carbon dioxide and the nonvolatile minerals are returned to the soil. Not exactly the same, and there is no doubt the fire is faster, but the end result is pretty much the same. My guess is the people who farm this way do this because they can grow more rice on each acre of land each year. If you couldn't keep doing this practice, my guess is that they would stop doing it.

So, you might believe the organic farm is sustainable, due to the magic of enhanced soil tilth (yes, another nebulous term) or improved soil quality. However, when the field is always tilled, soil erosion is more of a

problem. After all, it is only the top soil your organic farmer is losing. I will let you figure this one out.

Side note: the following section has a view that is harsh and extreme language is used. Reader discretion is advised.

People homeschool their children for a variety of reasons. Many times, it is based on a religious reason, in which they want to protect their precious children from all they will leam, see, and hear in the public school system. From one perspective this seems laudable. However, it also shows that the parents (and by extension their children) are only concerned with the "salvation" of their own children.

In a parallel view, organic food consumers show a lack of caring for those in the world that cannot afford food. ●rganic farms simply cannot produce as much as conventional farms, due to limitations of seed, fertilizer, and pest control. But, I am the arrogant rich. I can afford all the organic food I want. I guess all the others can starve.

CHAPTER SEVEN

FERTILIZERS AND THE GREEN REVOLUTION

The *English Oxford Living Dictionary* defines fertilizer as "a chemical or natural substance added to soil or land to increase its fertility." I believe it is kind of cheating to use the root of the word in the definition, but I guess I don't write dictionaries. Fertilizers are essential to modern production agriculture.

When you look at the actual mass of plant material, most of it is carbon, hydrogen, and oxygen, which the plants fix from the air. Carbohydrates are made during the process of photosynthesis. The plant then takes those carbohydrates and makes all kinds of stuff from those initial substrates. Photosynthesis is the foundation of essentially all life on the planet Earth, taking the sun's light energy and turning it into chemical energy. This is a fascinating process, which is well beyond the scope of this book. Although there is much concern about the carbon dioxide level rising, it is still a very low percentage, much less than 0.1%, and most of the studies actually show that *slightly* higher carbon dioxide levels will likely help plants grow better. I will not get into global warming or climate change in this book. Now back to fertilizers.

Some mineral nutrients that plants need to grow are normally in sufficient amounts in the soil so that they are not routinely added every year. These include minerals such as calcium or magnesium, and when the pH of the soil gets low, like < 6 or so, then these can be added using limestone, which normally doesn't cost too much, at least compared to fertilizers. Other mineral nutrients are needed in very small amounts, and normally are not limiting factors to plant growth. These are called micronutrients and include such chemicals as molybdenum, boron, and about 7 others. While in specific circumstances, growing a specific type of crop, a micronutrient may become limiting, and a farmer would need to add some of it, but it's usually applied at 5 to 10 pounds to the acre. Then there are the three primary mineral nutrients which are the focus of this chapter: nitrogen, phosphorus, and potassium. I will cover them in reverse order. A

fertilizer bag labelled 12-12-12 has 12% each of nitrogen, phosphorous and potassium.

Potassium, chemical symbol K, (which is the third number on a fertilizer bag) performs several major functions inside plants related to how the plant grows, transfers energy, and regulates water movement. It is fairly mobile and highly water-soluble within the plant. Fertilizer materials are produced by large companies that have large underground mines in a highly industrialized process. Potassium fertilizer is handled in bulk and shipped on barges and train cars around the world to where it is used. While prices vary over time, it's usually something about $200 a ton or so. Essentially all crops need to have adequate potassium levels to grow properly, and the potassium application is normally based on a soil test. As one removes more of the actual plant material from a field, such as when a dairy farmer harvests corn silage each year (he removes the entire plant from the field), then potassium levels in that field will tend to decrease more rapidly than other nutrients. This decrease is because the stalk of the plant contains substantial amounts of potassium, and so its removal will require replenishment. Too much potassium in the soil or in surface or ground water is usually not a problem for the environment under normal circumstances.

Phosphorus, chemical symbol P, is the second number on fertilizer bag. Phosphorus is essential to all living organisms and plays a major role in plants in photosynthesis and many other processes. It is also needed for root growth, which is one reason why farmers sometime apply a small amount in close proximity to the newly planted seed as a "starter" or "pop-up" fertilizer application. As planters have gotten to be bigger in size, farmers don't want to apply this starter fertilizer because it slows down the planting operation. Phosphorus is produced using large mining operations which are totally mechanized. Phosphorus is also processed into more concentrated forms and then shipped via barge or railcar to the end user. It is sometimes sold as a chemical also containing nitrogen, such as diammonium phosphate (DAP) which is 18-46-0. A ton of DAP usually costs more than Potassium, about 400 dollars a ton or so.

Usually, the phosphorus that is resident in soil is tightly held by the soil, although if the soil particles into which the phosphorus is attached move off-site then you can get phosphorus into bodies of water. Normally, waters, think lakes or streams, have very low phosphorus concentrations, *very low*, such minute amounts of phosphorus is normal in most water bodies. I hope you are getting what I'm trying to say about bodies of water

normally having very low concentrations of phosphorus. So, a little bit of soil washes into the stream, and the phosphorus concentration increases and this can dramatically change plant growth. Since the water ecosystem is used to having very low concentration of phosphorus, when this rate limiting factor is removed, you can have tremendous increases in plant growth including small plants called algae. These algae "blooms" will greatly increase the amount of algae due to having too much phosphorus. As the algae continue to grow, they eventually run out of nitrogen, or some other nutrient, and then they die. Now I have an area of water which has a large amount of dead algae, and it will now degrade and decompose. As these algae decompose they will remove most or all of the oxygen from the water causing the water to go anaerobic (remove all dissolved oxygen from the water), which the other living things need to survive in that water. This lack of oxygen can greatly harm the native species that were resident in that water. Phosphorus contamination of surface waters is a major challenge to modem production agriculture. The same challenge applies to phosphorus used in urban settings on lawns, golf courses, or gardens. In fact, phosphorus use is sometimes restricted in many localities. When one looks at the fertilizer bag sold in urban areas and urban stores, the phosphorus number is often zero or a low number. This is good for the environment, but not good if you are trying to grow a lawn that has strong roots on the plants.

By the way, phosphorus is essential to modern farming and production of food to feed all the people on this planet that would like to eat, (which is everyone).

I want to share a story with you, but I really don't know the source of it. I believe it to be true so I'll give my version. Several decades ago, there was a tremendous amount of malnutrition and hunger in the subcontinent of India. The Indian government asked an agronomist, or perhaps a group of plant scientists, from a developed country to visit their country and provide recommendations for what they could do to help alleviate this problem. The agronomist(s) toured the country and looked at the crops that were growing there. He stated the observation, "You have phosphorus deficiencies in essentially all of your crops. I recommend you provide phosphorus to your farmers at subsidized costs to encourage them to use more phosphorus." The Indian government made phosphorus available, I'm really unfamiliar with the process that the government used, and the result, at least according to the person who told the story, was more food and better fed Indians.

Phosphorus and potassium are often sold together in bulk fertilizer "blends", think a large concrete mixer that mixes up batches of particles that look like coarse salt of different colors. Potassium is usually a pink or a pinkish color granule and phosphorus is usually a dark gray. Nitrogen is usually white, but that nutrient is going to be discussed later. While some fertilizers can be sold in 50 pound bags to farmers, the vast majority of fertilizer is handled in bulk, and a human never touches the material, as it is all done by machines. As a person who first started his ag career as a fertilizer dealer, I can assure you that operating a fertilizer business can be challenging. The combination of fertilizers + moisture + metals results in equipment that slowly or rapidly is breaking down all the time. Maintenance of your equipment is an ongoing, never-ending struggle. I remember vividly trying to empty railcars full of potash (potassium) into which the rain had entered and so there was a big frozen clump of potash in the middle of the railcar. I climbed up on top of the car and poked this big chunk of frozen potash with a long metal rod. Then I climbed off the railcar and then hit the side of the railcar with the biggest sledgehammer I've ever seen. Oh by the way, your sales manager is reminding you that after three days on your railroad siding (think a parking lot for rail cars) the railroad company starts charging a fine which is called demurrage (bet you never heard that word before), so you better get those railcars emptied so the railroad can pick them up. Did I tell you it was about 10°F while I was trying to do all this? Oh the joys of fertilizer...

Phosphorus and potassium should be applied based on a soil "test." (No studying is required). Farmers take a 0 to 6 inch soil sample, send it off to a lab, and get the pH and the content of several nutrients based on chemical analysis. Based on these results, farmers know how much fertilizer to add to their fields. You can add phosphorus and potassium to the soil, and it will stay there, unless the soil washes away of course. The nitrogen that is added will not stay and can leave the soil through several paths, and I will add more on that later.

More dollars are spent on nitrogen to grow "grass-type" crops including corn, wheat, and rice than the other fertilizers. The fact that these are the main staple crops to provide calories or energy directly or indirectly to humans is why nitrogen is so important. All crops need nitrogen to grow. Nitrogen is a major component of chlorophyll in plants which is essential for photosynthesis, (also the stuff that gives plants their lovely green color). Nitrogen is also found in all amino acids, which are the chemicals that proteins are made of in plants and animals. Our atmospheric is about 80% nitrogen gas, but that gas is inert and not directly available to most

crops, including grass crops. Thus, farmers need to add nitrogen fertilizer to many of their crops each year. Once added, the nitrogen can be taken up by the plants or microorganisms, can leach into ground or surface waters, or be converted to nitrogen gas and return to the atmosphere. Synthetic nitrogen fertilizers are based upon the production of ammonia, which is primarily made using the Haber-Bosch chemical process, which takes nitrogen gas and hydrogen gas and forms ammonia under high pressure and high temperature conditions in the presence of a catalyst. The Haber-Bosch process is probably the most important chemical synthesis reaction on the planet, and my guess is you have never even heard of it. If you want to know more about this fascinating topic a good book to consider is *The Alchemy of Air* by Thomas Hager published in 2008.

Maximum plant growth is based upon the idea of a "limiting factor." A plant may have plenty of water, light, nitrogen, and phosphorus, but if the amount of potassium is insufficient, then the potassium concentration or availability will restrict that plant's overall growth. In many crops, nitrogen is often the most limiting factor. That's not to say that if there were no rain for many days and water could become the limiting factor in that situation. Any essential nutrient or growth factor can act as the limiting factor to put a cap on plant growth.

Some plants can obtain their own nitrogen from the air, including soybeans. The soybean root can get infected with the bacteria that form small bumps, called nodules, and inside these, the nitrogen is "fixed" into a form the plant can use. This phenomenon is very good and is one reason why US farmers grow many acres of soybeans each year. After the soybean crop is harvested some of the nitrogen remains in the soil for the next year, but not enough for a full corn yield the following year. Organic farmers rely heavily on various crops that can fix nitrogen to add to their production systems. Cover crops may be grown prior to their next crop in order to provide some nitrogen for the subsequent cash crop to be sold.

A phenomenon which has been termed the "green revolution" occurred in the 1950s and 1960s. It has been described as a time of large increase in crop production in developing countries achieved by the use of fertilizers, pesticides, and high-yield crop varieties. A significant contributor to this effort was a scientist named Dr. Norman Borlaug. In 1999, I was on sabbatical at Texas A&M University where Dr. Borlaug was a member of the faculty. I remember my wife and I had lunch with him, and even though he was a man of international renown, he was a humble and sincere man who cared for people. It was a great joy to spend some time with him.

Much of what Dr. Borlaug focused upon was the selection of wheat and rice varieties that were shorter in stature, so that if you applied more fertilizer to that field, they would not fall over, what farmers refer to as "lodging." The combination of abundant fertilizer, improved pest control, more effective equipment, adequate irrigation, and improved genetics for better yield all combined to produce much higher crop yields. I do not believe it is coincidental that the world population shows a marked increase at the same time as the "green revolution." The "green revolution" allowed for adequate nutrition of many more people and a major part of that was synthetic fertilizers.

Animal manures, historically, have been a major source of nutrition in agricultural systems. In previous centuries, half of a given acreage of a farm was used to produce forage for the horses, cattle, or oxen and then that manure was used on the crops. There is no doubt that manures are a tremendously important source of plant nutrients. Manures often contain high concentrations of phosphorus, lower concentrations of potassium, and contain nitrogen in variable amounts. A question I often hear is, "Why don't farmers simply use manure for their fertilizers?" Often the manure is distant from where the crops are grown, and the nutrient density of the manure is insufficient to justify shipping great distances. In areas of concentrated livestock (think cows, chicken, hogs) manure can be a big problem. I was at a meeting in Pennsylvania, and a speaker talked about certified MMPs. I was not familiar with this term, but the speaker explained that these were Manure Management Plans, and that the livestock operation had to have a certified plan on how they were going to dispose of their manure in an environmentally acceptable way. It was clear that phosphorus runoff into the Chesapeake Bay is a MAJOR issue. In a different chapter, I talk about the smell of manure which is also a challenge, but ammonia emissions from manure sources can also be a challenge for livestock producers. This is an area of increased scrutiny in recent years.

I mentioned this fertilizer chapter to my younger daughter, and she immediately thought of compost piles. I am not sure how to take that thought process, but I guess it's okay. Astute gardeners often have an "area" where they place vegetative materials, cooking scraps, yard waste etc, and then compost it, an ambiguous term to be sure. Side note: one should not put into the compost pile anything related to meat or from a pet that has eaten meat or meat byproducts, such as dog or cat feces. Effective management of a compost pile includes that you turn your pile "frequently," whatever that means. If you add some nitrogen to your pile,

the composting goes much better, go figure. People can also add "starters" of various microorganisms to get their compost piles actively "working." One can also just get a bucket of compost from an active compost pile, add that to your pile, and then turn it in to mix with the other contents and that should be effective. The general theory is that microbial activity will increase the temperature inside the pile, and this increased temperature kills all the bad microorganisms while the good stuff lives. Then all the nutrients can go on your garden. Actually, this can be a really good idea. But, this process takes an extraordinary amount of time and effort and the compost will only cover a small area, maybe several hundred square feet. While some livestock farms compost their manure, my guess is they do that to sell compost for income, since it is much easier to spread the manure directly onto their fields.

Why do farmers have to add fertilizer to grow crops? High-yielding agronomic crops remove nutrients at substantial rates:

Crop	Yield	N	P	K
	Bushels/acre	-------pounds removed in 1 crop-------		
Corn	200	180	75	55
Soybeans	50	190*	40	70
Wheat	50	60	30	20

*soybeans fix their own nitrogen, so none is usually added by the farmer.

There are two general types of fertilizer application the farmers use, maintenance or buildup. A maintenance application really just replaces what the previous crop removed to keep the field at a constant level of fertility. If the price for what the farmer is selling is relatively low, many times the farmer will only put on maintenance applications. If, based on the soil test, some of the numbers are relatively low, the farmer can use maintenance plus buildup in an effort to increase the fertility of his fields. If the farmer is only renting the farm for one year, that changes the decisions about how he is going to fertilize. For many farmers they sometimes only fertilize the corn crop and allow the residual fertility to be used and taken up by the subsequent soybean crop.

Organic farmers have many challenges to produce crops. A major challenge to long-term organic production is the nutrient mining of the

crops that decrease soil fertility over time. If this nutrition is not replaced, the crop yields WILL be reduced. Now, there is a small amount of primary minerals that are released from the soil each year due to normal "weathering" of the soil materials, but that is much less than what is needed. The organic certification process for what is a legal organic fertilizer treatment on organic farms is often very limited and can be expensive to the organic farmer. Long-term fertility, or a lack of it, may prove to be the greatest challenge to organic farmers. These changes may not be clearly evident during a short number of years after the transition to organic production and may take several cropping seasons to become fully manifested. Additionally, organic farmers may need to set a substantial percentage of their acreage aside to grow cover crops or other non-profit producing plants that will detract from the overall productivity of that farm unit.

Fertilizer is a major expense each year to commercial farmers, and for all practical purposes they must use it. Unfortunately, nitrogen and phosphorus sometimes leave the field and can cause real, (or at least perceived) environmental problems, such as the gulf dead zone south of the United States. Nitrogen can be in the form of nitrates and can get into surface waters and can cause "blue baby syndrome." This condition is when the oxygen level inside small infants is low, and thus the baby can turn an unhealthy skin color. I do not wish to minimize the severity of this malady, but my hypothesis is that some NGOs use the fear of this malady to spread the fear of nitrogen fertilizer use. "Blue baby syndrome" can also be caused by a congenital heart issue, or other factors, but that will not bring in any dollars donated to an NGO. I ask you, when was last time there was some sort of valid news report about an actual human in the United States suffering from blue baby syndrome that was caused by nitrogen fertilizer?

Farmers only use a fertilizer to get their crops to yield. Fertilizer is expensive and not a luxury item. Commercial agricultural operators only use fertilizer because they have to.

CHAPTER EIGHT

NEONICS, THE NEW DDT

If you google neonics (at least when I wrote this) the first result you will probably get is that it stands for neonicotenoids and then a link against Monsanto (which no longer exists). Monsanto did not even produce or sell neonics (except a little bit on seeds), but I guess a NGO could not resist linking even "Big Red M" to bee deaths. Does this sound sensationalistic?

Neonics are neuro-active chemicals that act similarly to nicotine. They were developed in the 1980s (Shell) and 1990s (Bayer). They were developed in large part because they showed reduced toxicity compared to previously used types of insecticides. Neonics were the first new class of insecticides introduced in fifty years, and they are commonly used around the world for broad spectrum control of insects.

Widespread use of neonics has drawn many valid comparisons to Rachel Carson's analysis of DDT and her chapter "and no birds sing" (what a great chapter title!). Neonics are widely used in agriculture, forestry, industry, and home uses. These chemicals are more widely used than most Americans know.

The truth is that the only thing neonics are really killing is insects and not only bad ones (think termites in your house) but also the most precious, most fragile of all species, the domesticated European honey bee (a genetically modified organism, by the way). To read the websites, one would think our fragile food web hangs on the brink of disaster if no honey bees existed… Well, let's look.

Crop	needs pollinators?
Corn	no
Soybeans	no
Wheat	no
Cotton	no
Canola	no, but sometimes used
Fruits	yes, usually
Vegetables	sometimes
Pastures for cows	no
Home lawns	no

The vast majority of broad acre crops do NOT require pollinators. They do not need them; they are just not necessary.

So, when was the last time you saw an actual honey bee? Or a bumble bee? Did you relish the encounter and find joy and happiness with your closeness to the bees? Why do they not have bees at zoos? Last time I saw bees (quite a large number, honestly) up close and personal, was at my daughter's insistence. Her bedroom was exposed to the world via an exterior wall. One day, she came and told me that some "bugs" were in her room. I investigated and found two or three honey bees inside her room. My daughter was terrified. Me being (no pun intended, but one realized anyway) a trained biologist, I knew bees are "social" creatures (interpretation: where there are a few, there are usually many more bees). I went outside and guess what I found in the corner of the house where the wood siding joined to the brick foundation? You guessed it, a swarm of bees under the siding of my house.

Now, I guess I could have called a bee keeper, waited several days for him/her to come and tear my house siding apart, find the queen, and move (and save) this hive. Did I mention that the bees kept entering my daughter's bedroom? Just above her bed? Now, for full disclosure, I did not use a neonic to perform a mass termination of this bee population. I used a pyrethroid, which has more rapid knockdown of hymenoptera species… About one hour later, no bees were present. I guess I am a mass

bee murderer (motive, opportunity, and means). No more bees entered my daughter's room. She slept better that night.

I do not believe the food web or any ecosystem was unduly altered, and we still have bees around to pollinate our flowers.

Why do NGOs focus on bee health as they wage war against the neonics? Well, who can be against honey bees? After all, they are cute, harmless, and essential for food production, right? WRONG!

Well, about one hundred Americans die each year from bee stings. Not so harmless, huh? And do you know anyone that has ever been stung by a bee or wasp? Not a happy time, huh? So, I ask you again, when was the last time you encountered a honey bee? Yeah, I know. You never have.

Well, let me tell you a story about honey bees. Firstly, there are many, wonderful local bee keepers that lovingly care for their bees and produce wonderful, tasty honey from their hives that stay more or less in one area permanently. No problem there. For "commercial" hives it is a very different story. We start the year somewhere down south in Texas or Florida, pollinating (taking care of) vegetables down there. At some time during the year, my hive (home sweet home... Again, no pun intended, but honey pun realized accidentally) is put on a truck and off I go north. It could be heading for Michigan fruit trees, canola (or other crops) in North Dakota or Canada and then out to the central valley of California for fruits, vegetables, and almonds (lots and lots of almonds in California). The technical term for problems with honey bees is called Colony Collapse Disorder (CCD, sounds pretty bad). In many situations, CCD is real and there is no doubt that neonics kill bees when they are directly contacted (and just about all other insects, too, thank you). But consider the effect on CCD from:

moving the hives (maybe multiple times each year),

varroa mites that attack the bees,

loss of habitat due to urbanization, development, etc.,

diseases such as Israeli Acute Paralysis or gut parasites such as Nosema, and

direct exposure to neonics (and all other insecticides).

Neonics are not the only stressor or problem to bees. My guess is that the

NGOs did not tell you that since a varroa mite infestation does not encourage you to send them money, but the evil corporations spewing toxic pesticides into our pristine environment to kill our bees… That might open the check book or go-fund-me page.

Neonics are great to protect wooden structures from termite damage, and are a more effective and less toxic alternative to organochlorines such as chlordane. Neonics used as seed treatments reduce the amount of chemical used by farmers, yet protect the young seedling plants from insect damage. They are safe to humans if there is accidental exposure.

Neonics are also more widely used than you think. If you buy flowers or shrubs from a "big box store" the plants have probably been treated with and have residues of neonics in or on them. Also some neonics last a long time (several months, for sure) in the soil. The persistence is good for long-lasting insect control but not good for environmental fate (how long a chemical lasts and thus maybe gets in the water we drink). For example, if you dose some tree species with imidacloprid, the treatment remains effective for several years. This is good (only treat trees every few years) and bad (what is the neonic doing to the insects that "visit" the tree?).

I like neonics used in agriculture. They are valuable to farmers and provide effective, economical insect control. I like neonics around my house to keep the termites away. I am not sure about all the other uses. Maybe that is because I am ignorant about these other uses, and my ignorance elicits a fearful response, and I am trying to flee.

CHAPTER NINE

RACHEL CARSEN WAS A GREAT WRITER

I have just finished rereading two books related to pesticides, one famous and one not so much. *Silent Spring* by Rachel Carson was probably the seminal book that catapulted the environmental movement to the forefront. When I ask people, I learn that essentially no one has actually read the book (a similar situation to other major books like say maybe *The Bible*…) Yet, many people believe they know what the book says. I read my copy (which happens to contain a bonus introduction by Al Gore), and it is a fabulous read. I strongly encourage you to read it. Granted, some of the ideas have been replaced by other issues, but several major themes predominate and resonate strongly even today. Big government may not always be good; DDT and all the pesticides are bad, and nature is fragile and must be preserved at all costs. The second book is *The DDT story*, and I will get to that book later.

Much of the book *Silent Spring* deals with the ideas of bioaccumulation and chronic effects of DDT and related chemicals to non-target species, especially birds. The book also has extensive sections which contain superbly written explanations of complex biological processes such as cell respiration. I found it fascinating! Whether you agree with her views on pesticides or not, there is no doubt of the huge impact this book had on America and on the world.

However, when she wrote the book in the 1960s, there was no US EPA (Environmental Protection Agency), no understanding of the bioaccumulation of the organochlorines, there was probably more obvious trust in the federal government (remember this was before the Vietnam War, before Watergate…) and there was a less tightly scrutinized regulatory system for pesticides. If DDT was "discovered" today it would never get an EPA label (something all new crop protection chemicals need prior to their first use) because they last (or persist) too long, they bioaccumulate, and they are toxic to fish and other non-target organisms. The US EPA screening of the chemicals used to reduce crop losses due to crop pests is much more thorough than it was in 1962. We have learned much in the last 50 years.

The other, much less known book, has the unbelievably sexy title *The DDT Story* by Kenneth Mellanby. Needless to say, it tells a different story about DDT, albeit a fairly balanced one. I would guess most readers of this book would find it hard to believe that the "inventor" of DDT won the Nobel Prize for medicine for his work. Still the benefits of early DDT use, saving millions of lives, outweighed the risks or the costs, such as ecological and other negative effects.

The DDT Story describes the work of a Swiss chemist named Paul Mueller (no relation, but I am sure he was a swell guy), who set out for himself the difficult task of discovering the perfect synthetic insecticide. He believed such a substance would have the following properties (page 6 from the book):

1. Strong toxicity to insects
2. Rapid action with insects
3. Relative harmlessness to warm-blooded animals and plants
4. Nonirritant and virtually odorless
5. Have a wide application
6. Long-lasting effect through chemical stability
7. Cheap and easy to produce in quantity

Dr. Mueller set out upon this quest in the mid-1930s, and after a systematic discovery effort, he published his work on DDT. Oh, by the way, he did work for a private company, which I'm sure made a huge amount of money from this molecule and similar chemicals that were produced later. Prior to DDT, which is usually considered the first synthetic pesticide, people used arsenic-based chemicals for pest control or plant-based controls based on pyrethrum flowers or nicotine, both of which were sourced from plant extracts. Besides the lack of efficacy and the other incomplete attributes of these previous insecticides, there were supply issues getting enough of the plants to be grown to produce the insecticides needed. DDT proved to be an effective insecticide for use in crops and in many other ways. It greatly increased food production at a time when the world's population was growing.

The DDT Story also shares a perspective on what happens when a chemical is put into the environment, in this situation an insecticide. "When insecticide is taken up by an insect, it may be involved in four different processes. It may be rapidly metabolized to a less toxic substance, and may therefore do little damage. This is thought to be one of the mechanism by which insects become resistant. The chemical may also

be rapidly excreted. It may be stored, particularly in fatty tissues. As long as it remains in the fat, it may do little harm, but it may have its effect during a period of starvation when the fat is metabolized and insecticide is released. Fourthly, it may reach the site of action and kill or injure the insect (page 26)." Unfortunately for DDT, and by the way this is true for all pesticides, some of these mechanisms resulted in the formation of resistance to DDT and the chemical no longer worked in many situations.

Another interesting idea from *The DDT Story* was the attempt by the scientist working for the private company (Geigy) in Switzerland to maximize efficacy or effectiveness of the chemical while reducing, eliminating, or avoiding any negative effects. "The importance of the formulation of DDT preparations, designed to control different insect pests, was recognized by the Geigy scientists in Switzerland as soon as DDT had been discovered, and much of the work of the chemical companies has always been to find out how to make the preparations lethal to specific pests and, if possible, less harmful to beneficial insects such as honey bees (page 29)." Given the current enormous public interest in pollinator health, I find it interesting that scientists were already concerned with this "bee safety issue" all those years ago.

One aspect of pesticide use is the benefit to risk ratio. I guarantee you, farmers do NOT want to spend any money on pesticides, and they only do so when their use makes them money. In a country with abundant, cheap, safe food, the benefits to consumers of pesticide use is often unclear. I assure you, the benefits to farmers of increased yield and increased quality are very clear. Unfortunately, given the disconnect between the farmers and the consumers; the consumers don't actually realize the need for pesticide use. In the absence of all pesticide use in the United States, our food production ability would be tremendously decreased and our yields would be decreased by 50% to 70%, possibly more. The price of food would probably increase by a factor of 3 to 10 times and the quality and the variety would decrease. So although consumers don't see the direct effect of pesticide use, they see the indirect effects.

One of the few criticisms I have of *Silent Spring* (again what fabulous chapter titles she chose for her book: Elixirs of Death, Earth's Green Mantle, and No Birds Sing, One in Every Four… and so many more! You simply must read this book!) is that it only deals with the downside risk of DDT use. Oh yes there are herbicides mentioned in *Silent Spring*, but they were canceled years ago and those mentioned are no longer used the United States or the world. The essentially correct technical discussion

sections of this wonderful book lend credence to the other largely slanted sections that may or may not be "true." Some people believe science is absolute, with absolute right and wrong. This may not always be the case, and in fact as a scientist of only minor repute, my guess is a lot of scientists are some of the most biased observers that I have ever seen.

To close this chapter on *Silent Spring*, I ask what about the millions of lives saved by DDT use? What about the lives saved by decreased malaria in Africa and many other poor countries? Do those people not count? I guess to Rachel Carson, they did not. The eggshell thickness of Peregrine Falcons, which is actually caused by a metabolite of DDT, matters more.

CHAPTER TEN

THE ENDANGERED SPECIES ACT: SHOOT, SHOVEL, AND SHUT UP

The Endangered Species Act (ESA) does not celebrate the value of a given endangered species, a plant or animal or fish or whatever on a particular list, being present on a parcel of land. There are some grants you can get for some money, but they are limited. The documentation of an endangered species on a given parcel of land normally restricts the use of that given piece of land once an endangered species is found and confirmed. For this reason, one possible pathway chosen by a landowner that wants to build a house on a parcel they have bought, let us say in California, is the following. Kill or destroy the endangered species (shoot), destroy all evidence of the endangered species ever being present possibly by digging a hole and burying it (shovel) and then telling no one of your actions (shut up). Then, you can build your dream home on that beautiful mountainside overlooking the vista you have chosen. Until the mudslide or the fire or the earthquake gets it. But at least for some people, to build a house they have to shoot, shovel, and shut up.

The ESA was passed by the United States Congress in 1973. It is one of the dozens of US environmental laws passed in the 1970s. The ESA serves as the enacting legislation to carry out the provisions in the convention on international trade in endangered species of wild fauna and flora. The act was designed to protect critically imperiled species from extinction as a "consequence of economic growth and development un-tempered by adequate concern and conservation." It was signed into law by Pres. Richard Nixon (from California, remember?) on December 23, 1973. Later Supreme Court interpretations indicated "the plain intent of Congress in enacting the ESA was to halt and reverse the trend toward species extinction, whatever the cost."

The ESA is administered jointly by two federal agencies, the US Fish and Wildlife Service (FWS) and the Commerce Department, specifically the National Marine Fisheries Service (NMFS). If there is a group of people who use more acronyms than the United States government, I don't know

who they are. Who administers the ESA is important, and I will touch on that later on.

The ESA was preceded by other similar, but less expansive, legislative efforts. The first major one was in 1966, and there were several other amendments and iterations over the years. One of the more recent ones in 2014, the 21st Century Endangered Species Transparency Act, would require the government to disclose the data it uses to determine species classification as being endangered. I guess I find it interesting why the government has to pass a law to say what the government does on any given action. Also, anytime you have the word transparency in the title of a law… Well, I guess that indicates something. Government and transparency, what an oxymoron.

If you were to ask a person what percentage of all species that have ever lived on the planet have become extinct, what do you think they would say? What will you, dear reader, say? Well, it is a big number, probably greater than 99%. So, dear reader, did you get that right? No? I didn't think you would. Just so you know I didn't know for sure myself. Well, most biologists believe large number of species were killed off by "cataclysmic events" (think dinosaurs and a large meteorite hitting the planet and causing a massive die off). Some scientists believe this happened (mass extinctions) several times based on the fossil record, and some believe we are currently in the middle of another "mass extinction" of "endangered species." So how do we balance ESA and survival of the fittest?

I believe it is safe to say that most of the species that ever lived on this earth (our dear, precious, fragile, tender Mother) have come and gone and are no more. So, either a Creator made lots of layers of varying life-forms (seems silly to me), or the planet has been slowly evolving life from simple to more complex over a long time (longer than a bad piano recital, which seems to last for an eternity). I'm not going to argue about evolution or creation, but I will share a view of ESA and how it relates to agriculture.

Why was it in the 1960s and 1970s that humans all of a sudden decided that the current species composition on this planet was and is ideal? So a given plant goes extinct. Well, another plant fills that niche in the given biome and on we go! If there are light, water, and nutrients available; something will grow there (I know, many are called "weeds," and they have been my life's work to study). So why was the ESA enacted in the

1970s?

Silent Spring (popular in the 1960s) opened the floodgates of environmental emotion. We, as a nation and world, felt we had to "do something" to "save our planet." As I write this in my hotel room today, in the bathroom is a sign to "please the planet" and to "reuse my towels." I'm not sure the planet cares, but I'm sure the maid would like less work. There goes Mueller being cynical again.

We as humans evolved/were created with an inner desire toward "something... some purpose... some reason for existence." Many people fill this longing with various "religions" and these "religions" take many forms: diehard Alabama football fans, fundamentalist Muslims, evangelical Christians, Manchester United (a.k.a. Man U) "football" fans from the UK, conservative tea partiers, left-wing liberal Democrats, and so on. Into this emotional melee, environmentalists seek to fulfill the longing for an enduring purpose. "I want to make my world better," reduce my carbon footprint, recycle more, etc.

So how does this relate to US agriculture? Note: the preceding section seems like a lot of background to get to the point of how ESA affects US agriculture. I agree, but some ideas do not fit inside a tweet, twenty-second news segment on TV or radio, or a simple Facebook post, or whatever "social media" platform you use. That is why I wrote a book, with chapters and all. My experience is that social media today is not very social at all and can be downright antisocial.

Agriculture, especially modem, intensive high-input agriculture, is the greatest environmental disturbance on the planet. Each year a substantial percentage of the Earth's surface (that delicate, thin crust of our Mother that nurtures and sustains us) is denuded of all existing vegetation (some natural, some invasive), and a farmer plants a few seeds (or perhaps plant parts or maybe a transplanted small plant, seems odd and redundant that last phrase doesn't it)? Then the farmer grows it and harvests the crop a few weeks or months later. The sheer audacity of this vulgar act repeated over generations by farmers! And why?! Why, dear reader, do we allow such an environmental travesty? It's simple really.

People want to eat. Today, several times a day. And tomorrow and the next and the next and the next. And every day. The benefit of modem agriculture is the enormously increased "carrying capacity" (an ecological term) of the planet when farmed using tractors and chemicals and

optimized varieties of crops. Numbers vary widely, but without modern agriculture, many billions of people would starve due to lack of food. What? You did not know that? Why, of course you didn't. For too many of us, food comes from the grocery store, or if you're really selective you get it at the farmer's market, only local, organic produce of course. (No pesticide-laden crap for my children.) Now back to ESA and how it relates to agriculture in the United States.

Most United States laws dealing with modern agriculture have a component of benefit/risk analysis. Do the good things (benefits) of this practice/chemical/new GM● trade/whatever outweigh the bad things (direct toxicity to humans, kills bees, kills fish, etc.) The ESA, however, has no benefit/risk analysis component. This is very important.

Many current pesticide labels have "buffer zones" in their use instructions (referred to as a "label"). Most farmers think the buffer zones are to protect the next field over, maybe a different crop is planted, or maybe a different farmer's field. In reality, the buffer zone is often due to ESA regulations to protect some endangered species, which in all probability is nowhere near that particular field where the pesticide was applied.

So, if the Monarch butterfly is listed as an endangered species, what will happen to weed control options? Plenty! Each year, Monarch butterflies start out in Mexico and fly throughout their migration pattern, which happens to be through a major part of the United States, including some of the most productive agricultural regions. The Monarch butterfly goes through several generations as it goes through its migration each year and at several locations it needs specific plants upon which to oviposit (fancy way to say lay its eggs); the eggs hatch and then go through several instars (stages of their life cycle) while eating that type of plant, make a new butterfly. Then they repeat the process. They get somewhere up north, (I know a nebulous term but I don't really know where the migration pattern terminates, okay) and then fly back to Mexico. The Monarchs need a specific type of plant in the milkweed family to complete their lifecycle. Most farmers consider these plant species as weeds in their fields because they are weeds. If the ESA is most fully implemented, all, or at least many, broadleaf weed control options in many US areas would stop because we would have to allow for the milkweed's growth to sustain the Monarch butterflies. You say this is crazy and would never happen. I'm not sure what crazy is anymore, but that's another story. The idea is that regulations can greatly impact any given activity.

Let's consider the 18th amendment to the US Constitution to prohibit alcohol. When you restrict/regulate something, for example alcohol, it becomes illegal and more expensive. When you deregulate it, for example alcohol with the 21st amendment, you have price decreases. Airline tickets, long-haul trucking, the Internet, and many others are examples where decreased regulations often result in lower prices. Pesticides are no exception. As pesticide regulations increase, a company usually spends about $300 million (here again numbers vary and may be as much a $400 million) to discover and register a new active ingredient pesticide. This new product has seventeen years of patent life, with most of that patent life being used on various types of tests (usually 9 to 11 years of testing, some of which is for ESA requirements). Then, the company has only the remaining 6 to 8 years of sales to make their money back. Oh by the way, anytime along the way the rules change, and they may have to do additional testing, or whatever the government decides is best at the time. It's no wonder we have very few new herbicides or other active ingredients for crop protection.

This discussion on ESA is shared as an example of how regulation which appears to be good (save the Bald Eagle, the beautiful majestic Monarch butterfly, etc.) can have unexpected consequences. If you ask somebody "are you anti-Eagle, or anti-butterfly?" they will of course say they support these beautiful elegant species. The trouble is the hidden cost of the regulation.

DowAgroSciences (now a part of Corteva) developed a new 2,4-D trait that can be used for post-emergent weed control in soybeans. In several states it's okay to use this new 2,4-D trait, but not in all parts of Tennessee. Why? Because someone has listed a plant on the ESA protected list. (Since I first wrote this, the use has been cleared, but the story is still relevant). This plant possibly could be Short's Bladderpod (*Physaria gobosa*). Short's Bladderpod (sounds funny just even saying the name, doesn't it?) is a flowering plant in the mustard family that has ESA protection. So, from a philosophical position, should this plant be protected? Should not evolution be allowed to proceed so we can get on to the next (by definition of Darwinian evolution, improved, yes?) plant species? The Short's Bladderpod does not even grow within farmer's fields, and yet, due to its presence within a given watershed, very real restrictions are placed upon a given use of a viable crop protection chemical. There are scores of other examples like these two (Monarchs, Bladderpod) that demonstrate the disconnect between laws and land users.

If one mechanically tills a portion of land in some parts of California, the owner must pay a small fee (about $6 per acre). I was visiting with a landowner from CA whose land had recently been "surveyed" and several endangered species of plants were found to be on his property. He told me he wished he'd have disked (tilled) the land and paid that small fine. I see this sentiment as a variation of shoot, shovel, and shut up.

CHAPTER ELEVEN

GLYPHOSATE: A ONCE IN ONE HUNDRED YEAR HERBICIDE

A friend of mine from Australia named Stephen Powles was the first person that I heard use the term referenced in the title of this chapter. In many ways glyphosate is an extraordinarily unique herbicide and that is why I spend an entire chapter on this one molecule. Through this chapter I hope to share with you my view on the biological differences, the tremendous financial impact on farmers and the world, and the social impact due to the transgenic, a.k.a. GMO (genetically modified organism) crops that have allowed for nearly ubiquitous use of glyphosate in crops.

Essentially, all of my previous writings have been in refereed journal articles, which means that they are carefully reviewed by people who do or do not know what they are talking about. It is a frustrating process, but in some ways it keeps incorrect information from the "published" literature. The story I share right now would never make it through peer review.

Monsanto had a practice to take the chemicals that they find in their various divisions, and they would examine them for herbicidal, insecticidal, and fungicidal activity. They would use a set protocol and would spray the chemical on various plants and see what happened. Their usual procedure was to spray the plants on Monday and then evaluate them on Friday to see what happened. After the sprayed plants had been examined, they would be discarded to make room for the next set the following week. But whoever was supposed to discard the plants, on Friday night or over the weekend, didn't show up on the day he was supposed to. So when the scientist looked at the glyphosate-treated plants on Friday, there really wasn't much to see. But when the scientists looked on Monday the same plants had some effects, so they let the plants grow longer and said, "Hey, maybe we got something here." Glyphosate is one of the slowest acting of all currently used herbicides. Now, I cannot prove the story, but it sounds reasonable and I've heard it from several sources familiar with the situation, so I include the story in the book. The name on the patent for glyphosate is John Franz, and he certainly obtained a great

amount of fame for this discovery. I know Monsanto has made millions of dollars from this discovery.

The researchers at Monsanto were looking for a herbicide to kill perennial weeds, especially grass weeds such as quack grass and Johnson grass. Chemically, glyphosate is an organophosphate, not going into the chemical details, which is a type of insecticide known to have toxicity to humans. So, at first the plant scientist could not get any chemists to work with him on the project, reasoning that nothing good could come of developing a toxic chemical. Glyphosate is a very simple molecule that is very inexpensive to make. It is highly water-soluble, so it is easy and not costly to formulate. To formulate a herbicide is to take the active ingredient and put it in a solvent, in this case water, and add other substances to it so it is easy to use for the farmer. The product lasts a long time on the shelf and is stable, etc. Farmers never spray pure active ingredients because that is not the best way to use them.

Glyphosate was first discovered and tested in 1970 with the first marketing taking place in 1974. The newly formed Environmental Protection Agency (EPA) was just established in 1972, and probably the youth of the agency allowed for rapid approval of glyphosate. I doubt if any herbicide will ever be approved in such a short time. The good things with respect to glyphosate's rapid labeling included a lack of acute or chronic toxicity. Acute toxicity is when it directly kills you by some lethal mechanism. Chronic toxicity is due to effects from exposure over long periods causing something to slowly kill you like a cancer or something like that. Glyphosate is actually less toxic than aspirin. It is not a reproductive toxin and shows no other negative effects on mammals. The International Agency for Research on Cancer had a different view on that topic, and I'll discuss that later.

The first internal discussions within Monsanto on how much to charge for the chemical were interesting. There were basically two groups. The first group wanted to go for maximum market share and sell a huge amount of product, so they recommended pricing about $20 a gallon, which would be about five dollars per acre. The other group wanted to price it as a premium product at $80 a gallon, which would make for a lower amount sold but very profitable per gallon. The $80 guys were successful, and that is what resulted in glyphosate's initial price. Most people in the business knew that the profit margins on glyphosate were high because they were selling the same herbicide for $20 a gallon in Brazil. Now why can you sell it for $20 in Brazil and $80 in the United States? Well, chemicals are

priced based on what a buyer will pay, not how much a herbicide costs. This is similar to pharmaceuticals in the United States today. A given treatment can cost $20,000. It does not cost the company that much. Now, the company says they pay for research and development with those profits. Well, yes, but the gross profit margins can be 50% or higher.

Monsanto found this novel herbicide and priced it at a high price, so they looked for ways to sell it. Herbicides must be used "selectively" meaning the herbicide kills the weed but not the crop. At this time in normal herbicide research and discovery, a company selects chemicals for use as herbicides based on two factors: (A) They kill weeds and (B) They do not kill crops, which are defined as good. By the way, weed control is subjective biodiversity reduction with the farmer playing God in deciding which plants live, in this case the crops, and die, essentially all other plants. Anyway, Monsanto looked for ways to sell glyphosate, which they branded as Roundup, to go with their other Western-themed products, such as Lasso, RamRod, and Lariat. Some of the initial ways were to spray before the crop emerged in a no-till situation. As the name implies, there is no tillage so herbicides must be effective at controlling the weeds. At this time in the 1970s and 1980s, there were several changes happening to allow no-till farming to work on many fields. There were better planters, that could slice through the heavy plant residue and precisely place the seed into the ground. The planters would also cover the seed with soil so that it would later germinate. These improved no-till planters had many adjustments so you could change settings for your particular field environment, wet or dry, much plant residue or not too much, hard or soft soil, etc. Even the small four row MaxEmerge planter (I know, a cool name from John Deere) I used in my plots does a great job of planting seeds into hard soil. I remember a time when one of the farm crew at my research farm forgot to raise the planter as he exited a field in my plots. He "planted" directly into a gravel road, some soil but mainly gravel, and a few weeks later about every seed sprouted and grew! Of course, being in a road they did not survive too long. Anyway, no till farming was made possible by engineers developing better planters. Farmers also started using a suite of chemicals at planting including a small amount of pop-up starter fertilizer to help the early plant to grow. (See fertilizer chapter for more discussion on that). The seeds could also be coated with insecticides and/or fungicides to protect the seed and young plant from insects and plant diseases. The varieties of corn and soybeans also were selected for improved early-season vigor, a nice way of saying that the seeds germinated rapidly and grew quickly soon after sprouting. And herbicides got better.

One aspect of "true" no-till farming is a lack of tillage. This means the farmer does not mechanically control any weed after planting by passing through his field with machinery. In no-till, the plant residue from the previous year remains, and this residue helps hold the soil and decrease soil erosion. Now, for full disclosure, this residue also keeps the soil cooler and wetter in the spring so many farmers still till their soils to get planting completed earlier. This is especially true in more northern parts of the United States and Canada, but the herbicides did improve so one could control weeds with no mechanical operations. Only chemicals.

In no-till farming you have to kill all the vegetation present at planting to allow the seed to have no competition as it germinates and starts its early growth. This herbicide use pattern in no-till is called a "burndown" application by farmers. While there are many possible choices of herbicides for this, two main ones emerged, paraquat and glyphosate. Paraquat was cheap, fast-acting and usually mixed quickly with other chemicals in the spray tank. Unfortunately, paraquat is also toxic when ingested and unfortunately there is an accidental death every few years. These deaths are completely avoidable by following label instructions and NOT taking some leftover spray and putting it into a soft drink bottle and putting it in your garage were a child could get this UNLABELLED bottle and actually drink it. These actions are totally stupid and tragic. By the way, EPA is taking steps to make paraquat, which is a great herbicide, safer for users. The primary registrant has already added three things for safety including a color (blue), a stench (mercaptan smells like a skunk) and an epicac (to make one remove the chemical from your body if you do manage to ingest it). Paraquat poisonings have greatly decreased since the changes in formulation. The EPA is also considering further restrictions on the chemical so that it can only be used by commercial users with the specialized application equipment. Paraquat kills only the very small weeds and then only kills the aboveground plant parts. It is no good on perennials or larger weeds, but glyphosate is.

Glyphosate kills annual weeds: those plants that start from seed in the spring, grow into mature plants and form new seeds in one year. Glyphosate kills perennial weeds: those plants that grow for several years. Glyphosate kills grassy weeds, such as crabgrass, and it kills broadleaf weeds, like poison ivy. It can also kill very large plants, such as trees. It kills all these types of plants but has essentially no soil activity. Yes, some weed scientists can find glyphosate in soil, especially in sandy soil exuding from the roots of treated plants, but that is no big deal. So, what farmers used to do before 1995 was spray glyphosate before planting, or at

least before the seeds germinated, then use other chemicals after the plant emerged. Glyphosate had first sales in the mid-70s. It was a successful product in its own right but that changed in the 1990s. The new biotech procedures allowed scientists, really anybody, to take genetic material from one species and put that genetic information into a different species. While there are two main ways to do this, gene gun and Agrobacterium vector, the real challenge was to shoot the desired DNA into a group of cells, called callous, and then get the cells to make a plant that had seeds AND also had the DNA you wanted AND produce that DNA in the plant part you needed it in, etc.

It was very difficult.

Monsanto scientists did it.

They took DNA from another source, placed it into soybean or cotton cell callous and did many, many attempts to get glyphosate resistant crops, meaning glyphosate would not hurt or damage the transgenic crops once sprayed onto the foliage.

I remember the first time I personally viewed glyphosate resistant soybeans. My university has a field tour for farmers called the Milan No-Till Field Day (a catchy name for sure). While I was at this field day, another scientist from my university showed me a very small plot, only four rows wide and about 30 feet long. Two rows on one side were rows of dead soybeans and dead weeds. The two rows on the other side had living soybeans, but all the weeds were dead. All 4 rows had been sprayed with glyphosate about 2 weeks before. I remember my thoughts at the time, "If they can get these to yield, this will change my life forever." On a side note, the soybeans I was looking at were a preliminary line and in fact they had one major problem when grown in the field: no seeds on the plants. In later lines, Monsanto fixed this problem. Although for the first few years, Monsanto was accused of their seeds having a "yield drag."

Being the excellent marketers that they are, Monsanto called the seeds RoundupReady (RR). They went out and bought a soybean seed company (Asgrow), a corn seed company (Dekalb), and a cottonseed company (Delta & Pine Land Company, although that purchase was not initially allowed). The first RR soybean sales were in 1996. They had a 90% market share in less than five years. This was one of the most rapidly adopted new technologies in agriculture. So Monsanto was making the profits on the seeds and on the glyphosate. The seeds sales were a major

"game changer" in agriculture.

While some private companies produced soybean seeds prior to RR, this business was not hugely profitable, at least not as much as corn or cotton seed businesses. Farmers could legally save soybean seed from one year for the next, so there were not huge incentives for seed development in soybeans. Additionally, universities would release "public" varieties for their farmers to use, with emphasis on yield, disease resistance, yield, drought tolerance, yield, harvesting ease, yield, nematode resistance, etc. I asked a public breeder one time what the three most important aspects of his soybean varieties were, and he replied the first is yield, the second is yield and the third is yield. Now, RR soybeans added great value to the seed. The big difference was that once a farmer bought RR seed he signed an agreement saying he would not save any seed for use the next year. The cost of soybean seed went up. Way up!

And everybody bought them.

Some people tried to save seed and not pay Monsanto's royalty fees, even though they had agreed not to save any seed. So, Monsanto sued some of the farmers to "make an example" of them. You can imagine how popular this made Monsanto with farmers. Now, farmers could still grow soybeans using non-RR soybeans, which came to be called "conventional" varieties. But, few farmers did that. Why? Well, RR technology really was that good. For a farmer, I can now spray one herbicide on all my crop acres and kill 100% of the weeds and have 0% crop injury. With no soil activity, there are no herbicide residues at the end of the year restricting what I can grow next year. And there was more; unexpectedly more.

Roundup had normally been used on perennial weeds as a spot spray or as a non-selective burndown early in the season. It had not normally been used in the heat of summer. Well, faster growing weeds died faster from Roundup applied in warm temperatures, so what used to take a week or two now was happening in just a few days. Another new learning was that Roundup would kill really big weeds. For other herbicides, after some weed species got too big (think 12 inches or so) that herbicide would no longer kill that weed. Now with Roundup, you could increase the rate and "rescue" your fields from large weeds. Note, this is not the ideal way to use Roundup, but life happens.

Well, with no soil activity from glyphosate the fear was that you would have lots of late-season weed escapes. Well, no you didn't. The soybeans

were planted in narrow rows and they formed a complete crop canopy that precluded any weeds from growing. Essentially, the crop provided its own residual weed control. Many farmers were pleasantly surprised by how unbelievably clean their RR crops were at harvest. An unexpected outcome of this 100% complete weed control was that wildlife populations, which had utilized the few weed escapes as food sources, were sometimes decreased due to lack of food for them.

Before RR, many herbicides would cause some cosmetic crop injury. The response to the plant did not reduce yield, but it looked bad (yellow/brown leaves, twisted stems, smaller plants, etc). There was one herbicide that caused so much post-emergent injury to soybeans, weed scientists would jokingly tell the farmer to spray it and don't look at the field for seven days after treatment. There was essentially no crop injury from glyphosate when applied to RR crops. Well, there was a competitive glyphosate from Zeneca (another competing company) called Touchdown that caused a "yellow flash," but Monsanto got very mad when we made a report on that. Oh, and the early RR cotton varieties did not have good crop safety. We joked that they really were not "ready" for Roundup, but later RR cotton varieties had good crop safety. One difference with Monsanto compared to other seed companies was their "speed to market" (getting a new product available for sale) was more rapid. This was a major change in the seed business in agriculture.

Before RR crops a farmer had to visually inspect his fields (we call this "crop scouting") to determine which weed species were present, how big they were, how many of each weed, and then determine which of many potential herbicides to spray. Given the need for good control, soybean weed control cost about $40 per acre (or more, depending on what weeds, etc.), and multiple herbicides were routinely used. All that changed with RR crops. I remember the way another weed scientist put it as he described RR soybean weed control, "You go out and spray Roundup each Monday until all you got in your field is beans." The greatest single factor of RR crops the farmers loved was simplicity. There was no scouting, and there was no complicated decision of what to spray and not too much worry about when to spray it. With traditional herbicides the mixer and the spray operator had to be careful, too much herbicide would cause crop injury while too little would result in incomplete weed control. Also, as the spray operator drove the equipment if you overlapped your "boom" (the part of the machine where the chemical spray comes out) you might get some crop injury. Well, with RR crops there is only one chemical to add and no problem with overlap, since there was no injury, and if you miss

some weeds, the Roundup will kill them the next time. This is too easy! For the farmer this meant more time for maintaining machinery, marketing his crops, meeting with the bankers, attending the kid's soccer game, etc. Now, at first some of the varieties were not always great. Farmers did not care. They bought them all. In later years, with the huge profits the seed companies, such as Asgrow and Dekalb, breeding programs did make substantial improvements in crop yields. Better weed control, no crop injury, idiot proof application, a safe herbicide for the workers (more on that topic later), what could go wrong? Well, three possible negatives include the topics of GM●, drift, and evolution of resistance.

I ask my classes each year, and I sometimes ask the audience when I speak about agriculture, what is the most "successful" RR crop? Very few get the correct answer, which is sugar beets. Sugar beets (*Beta vulgaris*) is a fascinating, challenging, highly political, and profitable crop. Twenty years ago, sugar beet farmers would till the field, plant their seed, spray several series of expensive herbicides (each would slightly injure their crop), mechanically till between the rows, and oftentimes pay workers to "walk" the field and hoe out any remaining weeds. All this for weed control. Sugar beets are also EXTREMELY sensitive to herbicide carryover from the previous year, and in fact some herbicide labels will not allow sugar beets to be planted until forty-eight months after their application. So, Monsanto has piles of money to do research. What crop would be a major benefit to growers and also one the farmers in Europe would love to grow? You guessed it: sugar beets. Monsanto develops RR sugar beets even though Europe hates GM●s, and by extension Monsanto. It is unclear to me if Europe hated GM●s and then Monsanto or, if they hated Monsanto and therefore also GM●s. Still, Monsanto believes (at this time in the past) that the technical benefits of RR sugar beets will get them a "foothold" into the European market. By the way, the Europeans are already buying and consuming lots of transgenic crops. European farmers are already routinely using glyphosate in their farming operations, so Monsanto believes this should work. But, their timing to launch and to introduce RR sugar beets is bad, very bad. Just before they announced their plans to introduce RR beets into Europe, several high-profile events reduced the European citizens' trust in their governmental regulators. You might recall the following stories:

1. Mad cow disease in England
2. Food contamination in some European countries
3. General mistrust of government safety groups.

All these concerns, from a largely urban population who really do not care about weed control in sugar beets, and you know they already hate Monsanto. Well, the European launch of RR sugar beets never happens. But in the United States, once sugar beet farmers try them, they never go back to "conventional" sugar beets because RR sugar beets are too easy. There were some interesting gyrations in the path of RR sugar beets getting to market in the US, but that is for another time.

Sidebar story on sugar beets. The sugar lobby in the United States is powerful. I remember I was at a meeting in Washington, DC and the sugar lobbyist announced, "We will keep our sugar program through the next administration..." Now to be honest I don't really understand what the sugar program is, but I do eat a lot of sugar, so I guess I'm for it. When I was at school at University of Georgia for my PhD, peanuts as a crop were extremely profitable due to the government programs. A few years later the government canceled/changed the peanut program, and farmers' revenues for peanuts greatly declined. Now, did the price of peanuts, peanut butter, or peanut oil go down? No it did not. By the way, some farmers still grow peanuts but it isn't the same. Now back to sugar. So, RR beets are transgenic, a GM●. The other source of sugar in America is sugarcane. Sugarcane is non-GM●, so those growers want to label and market and sell it as a non-GM●. No problem, right?

Guess what they spray on sugar cane as a harvest aid to knock off the leaves and increase sucrose content in the cane? Glyphosate. So cane sugar has glyphosate residue in it and sugar from sugar beets does not, since glyphosate is long gone from the plant due to how it is used. So I suggest the sugar folks to be careful how you market your sugar, do you wish for non-GM● or glyphosate-free sugar? By the way, your sugar is safe to consume, although excess of amounts can rot your teeth, make you fat, or kill you from a heart attack.

I was not sure where to put this topic in this book, so I decided to put this in here about a comment on marketing herbicides. Glyphosate is the active ingredient in many commercial herbicide formulations. The most widely known and used in the United States is Roundup. Now the actual active ingredient has never changed and is the same acid of glyphosate. However, the trade names have changed many times. The trade names have included Roundup, Roundup Ultra, Roundup Ultra Max, Roundup WeatherMax, Roundup Pro, Roundup PowerMax, Roundup PowerMax II, and I probably missed some. So why the many changes? Well mainly two things, including the glyphosate salt that is associated with the parent

molecule acid has changed various times (not gonna bother you with the details of isopropyl amine versus potassium salts) and the surfactants in the formulation. A surfactant, surface active agent, is needed to get the glyphosate to move inside the plant and hopefully kill it. Think of surfactants as soaps that get the chemical into the plant. As an advisor to farmers, it is confusing and frustrating when the companies keep changing the herbicide names. I remember fondly a weed scientist from Illinois making a presentation on the herbicide companies changing product names without really changing the chemicals. His title was "Can'em and Confuse'em." I think the old DuPont Ag company, now part of Corteva, was the "worst" or "best" at this tactic, depending on your point of view. I once asked the Roundup product manager why they changed the name so frequently. He said that if the company did not "refresh the brand" periodically that a certain percentage of people will try something new. Given the enormous success Monsanto has had, it is hard to argue with them.

So, what's in a name? Well, it depends on who you ask. The Scott's company, a company that focuses on lawn and garden business, did market research and they found a high level of trust in the name Roundup, one that implied good weed control and safety. So, Scott's bought the rights to the "Roundup" brand in turf markets. Now, they call many products by the Roundup name, some which contain no glyphosate. I find this to be very confusing.

I guess I have delayed long enough the most pressing question concerning glyphosate. Is it safe? Does it cause cancer? Well, I am not a formally trained toxicologist, but not knowing something has never stopped me from talking about it before.

In general terms, risk = exposure*toxicity

Risk, sometimes called hazard, is defined in the *English Oxford living dictionary* in several ways, and I will select the one that says "the possibility that something unpleasant or unwelcome will happen." With respect to toxicology, the unpleasant event is death, illness, or some other negative on a given life form. Exposure is considered to be that aspect where a life form comes in contact with or is exposed to a given chemical or agent that may cause harm. Toxicity is the inherent ability of a substance to cause harm to another life form. Something can be extremely toxic, but if you never are exposed, there's no risk. Conversely, you can be widely and profoundly exposed to a given substance, and if it's not toxic it

doesn't cause any negative effects. In the published scientific literature there are literally thousands of papers on glyphosate, actually there's about 10,000 papers with about 1100 dealing with the toxicity of glyphosate on a wide number species. As a scientist I should try to persuade you that because of the studies it shows yada yada all that stuff. I'm not going to answer the question this way, but I will answer from my own personal experience.

I have been directly exposed to Roundup many times. I have never ingested the product, nor have I inhaled it, but many times it has gotten on my skin. In a perfect world, people use full personal protective equipment (PPE) and on your truck if you are spraying in the field you have a decontamination kit, containing clean water, soap, and paper towels. Sometimes you may be out in the middle of a field spraying various herbicides and say you get some grease on your hands. You go to your decontamination kit and you have water and paper towels but no soap. Hypothetically, one could use Roundup (just a small glug) onto your hands, add water, and clean off the grease quickly. The first formulations of Roundup had wonderful surfactants in them which were good at removing grease from hands. One would rinse with water, and now the hands are clean and grease-free. This is all hypothetical, of course. I also routinely got glyphosate on my skin while spraying areas around my house. As I write this, I'm 57 (almost 58) years old, and I do not have cancer. People who work at glyphosate production plants are extensively monitored and they are not getting cancer or ill in any way. This is in stark contrast to shipbuilders after asbestos exposure and the negative effects of that, for example. Here again most scientists would start quoting studies and experts and say how many numbers of clinical trials show glyphosate is safe etc. Many of you do not believe scientists, a view that is not all bad I might add, so let me ask you this. If I were to place a chemical directly on my skin, do you think I either:

A. Believe it is truly safe

B. I am totally stupid

C. I am ignorant (not the same as B)

D. I wish to die

Now, I know some of you may go for B, but I hope you believe it is A. So, why do so many people believe otherwise? When the answer includes NGOs, lawyers and IARC.

In March 2015, the International Agency for Research on Cancer (IARC) issued a report calling glyphosate a "probable carcinogen." IARC is based in Europe (France, I think), which is not exactly the most "glyphosate-friendly" part of the world. Other organizations took this IARC finding and used it to share their view that glyphosate is bad. I guess this is how I will respond to the IARC report. If I am a carpenter, and the only tool I have is a hammer, then everything looks like a nail, and I hit it with the hammer. If the only thing I care about is cancer research, (i.e. IARC), then I guess everything causes cancer. Groups of people self-select their beliefs, based upon their prejudices. My guess is that if one looked deeply enough, then some components of red wine from France would cause cancer. My guess is the IARC would not find those chemicals to be "probable carcinogens."

The other response to glyphosate safety is the enormous use on crops, transgenic and others, and the huge "feeding study" we on Earth have been conducting over the last twenty years or so. We have had massive use of transgenic RR crops and massive use of glyphosate, and what is the main negative in the US population? Obesity.

It is not widespread cancers from glyphosate or RR crops, it is too much cheap, abundant food.

Another chapter deals with NGOs and how they need to have an emotional catch to get you to send the money. Monsanto accomplished many great technological breakthroughs, and they were effective marketers, but many times their public relations efforts were abysmal. The perceived attitude was "our technology is so good, you have to use it." This arrogance was seized upon by NGOs to the detriment of Monsanto.

I have several lawyers in my immediate family. I love them because they are in my family and surely not because they are lawyers. Practicing law in United States, which I will not comment upon for fear of being sued, is different from many other occupations because in court there are often direct adversaries as well as clear winners and losers. Many times judgments result in millions, sometimes billions, of dollars paid from one group to another, and the lawyers get their percentage. In our sound-bite, twitter world we often do not know "the rest of the story," a quote from the late radio personality Paul Harvey. For example, the food sales company McDonald's lost a lawsuit because a lady spilled hot coffee on her lap, so she sued McDonald's and won the case. Ridiculous, right? Well, the case actually was about inferior quality cups that might lead to

coffee spills. Did the company know about the potential risk, hot coffee burns and faulty cups could allow direct exposure, and did this imply negligence since the Big Bad Corporation was trying to save a few dollars and use cheaper cups? And this version is only a very simple description of this story. So it is not exactly as clear cut as it seemed, huh? Monsanto recently lost a big court case in California but more on that later. NGOs drive public opinion by posting websites that disfavor glyphosate and GMOs, etc.

Now, to the California court case in District 9 with respect to glyphosate. A maintenance person from a school district claimed using glyphosate caused his cancer. He said he was routinely "drenched" with glyphosate, which is not on the label due to instructions just so you know. If glyphosate does not cause cancer, how did the lawyers win the case? Simply, they put the Monsanto Company on trial and showed through lots of emails etc. that somehow Monsanto was negligent. A jury of "average citizens," (don't get me started on jury duty in the United States) sided with the poor maintenance guy over the super-rich Monsanto. The first award, which was about $180 million or so has already been reduced to "only" $20 million, and there are thousands of other plaintiffs ready to sue in various class-action lawsuits. I'm not sure how all this will end. Glyphosate to me is safe. No doubting to this Thomas.

But Roundup is not only glyphosate. It is sold in formulated products containing other chemicals which are called "inerts." The truth is, sometimes these inerts are more toxic than the pesticide, and early formulations of Roundup were harmful to aquatic organisms, not to humans. I guess don't spray your frogs with Roundup. Note: I don't think the inerts cause cancer either.

The other two possible negative outcomes of RR crops are drift and herbicide resistance development. Herbicide drift occurs when small spray droplets from one field move in the wind to the next field. This could have been a major problem since glyphosate is pretty good at "controlling" corn that is not RR. One main reason this did not affect too many farmers was that farmers settled damages between themselves and also as everyone went to RR crops, drift from RR crops on to RR crops was not a problem. Still, glyphosate drift did cause some problems. In Arkansas, they grow several million acres of rice which is not RR, nor is it GMO. In Arkansas they also grow several million acres of RR soybeans. They are grown in close proximity to each other. When I spray my RR soybeans and I get some drift onto the small rice (like 4 inches tall) then the rice normally

grows out of it without too much problem. However, if the drift happens to larger rice near the time of harvest, the rice plants can look okay, but, when the farmer "puts the combine into the field," the yield can be greatly decreased, like 20-70% decreased. At this point in time there is no way to determine where the glyphosate came from and which field or farmer. Note: other causes can also reduce rice yield, so it might have been something else. Maybe...

Glyphosate drift onto non-crops can also be a problem. Gardens, orchards, etc. are all susceptible to glyphosate damage. As the wind is blowing the small spray droplets drifts towards them and away from the treated field. The fact that glyphosate is essentially non-volatile and doesn't evaporate easily, means that most of the drift problems occur right at the time of application. Although not perfect, the drift problems from glyphosate applications haven't been a huge problem to most farmers.

In 1996 RR soybeans are first sold and rapidly take the herbicide market, which decreased the value of herbicides about 50% in the United States. In a few years, glyphosate was used on ~60 million acres of soybeans, ~50 million acres of corn and 5 to 10 million acres of cotton each year until 2000 and beyond. There is an idea that evolutionary processes will select the most "fit" individuals from the given populations. Not very surprisingly, Monsanto published a paper in 1997 saying resistance to glyphosate would not happen. Resistance means no longer controlling a weed that herbicide used to control; the same phenomenon as when antibiotics no longer control human diseases. In 1998, in Delaware a weed called horseweed (*Conyza canadensis*), although most farmers call it marestail, was first reported not to be controlled by glyphosate. Glyphosate used to kill it but afterward it did not. This phenomenon rapidly spread around the United States including Tennessee, where I live. Other weeds followed including a particularly bad weed called Palmer pigweed. Palmer pigweed (*Amaranthus palmeri*) is a particularly troublesome weed because it grows so fast, produces lots of seed, and is very difficult to control. These weeds, and others that glyphosate no longer kills, have made the RR crops + glyphosate system non-functioning in many areas of the United States. There are many fields where there are multiple glyphosate resistant weeds, and this is a real problem for farmers. This means the golden age of weed control, the RoundupReady era, has come to an end. The times were good while they lasted, but now they are over. Through the "decline" of RR crops, Monsanto worked diligently to maintain its market share. When someone first would report a glyphosate failure in a new weed, Monsanto would say the weed was too big or the

weather too cold or some other excuse. The truth is, the technical experts inside Monsanto, and outside too, knew what was happening, but the Monsanto marketing group would say, "Can we get one more year of sales from this product line?" By the way, Monsanto as a company no longer exists. They have since been purchased by Bayer Crop Science, which is based in Germany.

Glyphosate was, and still is, a special herbicide, a one in one hundred year herbicide as referred to by my friend, Stephen Powles, in Australia. Biologically, it transformed agriculture as no other herbicide ever has with its coupled use with transgenic glyphosate resistant crop varieties that added great value to the seed businesses. Financially, the value of glyphosate for weed control is several billion dollars every year. Socially, it allowed for farmers to increase operation size because they could control all their weeds independent of how large their farm was. It allowed for no tillage systems to reduce soil erosion and help clean the environment of whatever was on the soil that you don't want in the rivers and lakes. It is unfortunate that so much negativity has been associated with all this new technology. The reality is that we now have several billion people to feed, without herbicides and transgenic crops there are going to be a lot of hungry people.

CHAPTER TWELVE

ROUNDUPREADY CROPS AND UNEXPECTED OUTCOMES

In modern agriculture over the last 100 years there have been four "eras" of weed control. The pre-chemical herbicide era (< 1950 or so), the conventional herbicide only era (~ 1950 to 1996), RoundupReady (RR) era (1996 to variable), and the post RoundupReady era (~ 2002 to present).

In the pre-herbicide era there was substantial yield losses due to weeds of various types. Weed control was by cultivation with horses or tractors, or you could have humans pull them up by hand or hoe them (mechanically remove) etc. Weed control was time-consuming, slow, agonizing and largely ineffective. It had a high labor requirement per acre to attempt to reduce weed losses. Just for the record, there were also major losses due to insects and diseases at this time. As a side note, it's interesting to note that in the early part of the 1900s half of the farmer's production would go to produce feed for his horses or other livestock, and thus they would not have crops available for sale from those acres.

The introduction of the 2,4-D molecule in the late 1940s introduced farmers to the potential to control weeds by using herbicides. Originally, there were two very important aspects of a given herbicidal molecule which is usually denoted as an active ingredient (AI). A particular molecule had to simultaneously kill weeds (a term scientists call efficacy) but also not damage the crop of interest (a term scientists call crop safety). While there was some toxicity testing, the truth is the full environmental profile of the early AI molecules was not carefully examined. Originally there were many companies working to discover herbicides during the 1960s and 70s, maybe thirty companies in total. It was a time when new herbicides and novel ways that herbicides work (the modes of action or MOA) were being introduced "all the time," or at least every year so. It is with sadness that I note that the last new mode of action was introduced in 1988, a decade before the RoundupReady era.

The RoundupReady era, starting in 1996, should be considered the golden age of agronomic weed control. For some fortunate farmers, they are still in the RoundupReady era. RR soybeans were introduced in 1996, and the adoption was extremely rapid such that by 2000 RR soybeans market share was greater than 90% in the United States. RR cotton was also rapidly adopted in many parts of the country. RR corn originally was a bit slower, but it eventually also became commonplace.

So, what exactly is the RoundupReady system? I'll be happy to tell you. Monsanto was selling Roundup (with the active ingredient being glyphosate) in a wide variety of uses. Roundup is a nonselective herbicide that normally will kill all plants. It kills grass plants and it kills broadleaf plants. It kills annual plants and it kills perennial plants. Glyphosate has a good toxicological and environmental profile; all the rubbish on the Internet is completely wrong. So, Monsanto scientists used the "newly developed" biotech methods and took some DNA from another plant, inserted that DNA into the desired crop (soybeans, etc.) and then grew those plants out so that you could now apply Roundup over the top, directly to the plants and they would not be hurt. AMAZING! But, all the weeds would die. This was great!

The RR era had several consequences. It made Monsanto and its various seed companies (Asgrow for soybeans, DeKalb for corn) huge profits. There were other aspects besides just weed control including insect tolerance via transgenic traits, but the herbicide was a major factor in their success. Other aspects of RoundupReady crops were covered in the glyphosate chapter.

Farmers love the RR weed control system. I only have to have one herbicide, I can spray whenever I want to, it always works to provide complete weed control, and I have no crop injury, at least not on my RR soybeans. There is no need to scout (this is to visually inspect or actually get out of my truck and look at their fields) since Roundup kills all the weeds. This allowed farming operations to grow in size since complete weed control was possible and actually was pretty easy.

If you get the idea that RR crops changed agriculture in the United States, you are correct. It was a transformational technology that changed weed control for a generation. Given the devaluation of the market for herbicides, many companies discontinued herbicide discovery research. Others scaled back or reduced their efforts in this research area, reasoning they could not compete with the RR crops and low-cost glyphosate. In

some ways we are still in this situation today. Monsanto as a company took a big chance that they could transform agronomic plants and produce RR crops. It worked. In the view of some people, however, at this point they became arrogant. They reasoned "our technology is so good that you have to buy it-even if you do not want to." Monsanto openly sued farmers when they broke their contracts and saved seed. Over time, Monsanto worked less and less with university researchers (as one of them, I know). At least some of the Monsanto scientists had the attitude "we already know it all, why should we work with university researchers?" And, Monsanto has lots of lawyers. Many, many lawyers. And they are very good, although I'm not sure how to define a "good" lawyer. Talented, I suppose. Side note: Bayer bought Monsanto in 2018, since I first wrote this, so Monsanto no longer exists.

Depending on where you farm, the RR era ended years ago, or you are still enjoying it. I was recently traveling out West in the United States, and the county I was in has a highly diversified crop mix. Their occasional use of RR corn and glyphosate is working great! Good for them! In other places, like Western Tennessee, we have plant species (weeds) that are no longer controlled by Roundup applications. While not always in the same field, the following weeds are all found near Memphis, Tennessee, and are no longer are controlled by glyphosate: horseweed, Palmer pigweed (this is the worst one), giant ragweed, goosegrass, Johnsongrass, barnyardgrass, and ryegrass. So why, if Roundup no longer works, do farmers still want RR crops? Well, the Roundup is still killing lots of other weeds. The RR varieties have good yields and other agronomic traits. Monsanto and its affiliated companies are very good at marketing and have a series of incentives to get you to buy their seed. And sometimes depending on the crop, there's not enough non-RR seed available. And this is where we are today.

So, what are/were the unexpected consequences of RR crops?

Firstly, there's no direct benefit to food consumers of RR crops. There is a huge and clear benefit to the farmers. So, the apparent benefit/risk ratio goes like this to a soccer mom (or soccer dad, I guess):

1. There is no benefit to me from RR crops.
2. I do not understand GMO/GE/BE.
3. The fear of the uncertain (one of the greatest fears for all humans is the fear the unknown, and Lord knows consumers have no idea how their food is grown) manifests itself.

4. Increased fear then focuses solely on the risk. (BTW, some NGOs sense an opportunity and played on these emotions to solicit funds. When I checked it, an NGO website opens with an opportunity to sign a petition to ban glyphosate.)

So you have some NGOs spreading fear to try and get some funding. You have Monsanto: arrogant, we know everything. So you put the two together and you had the perfect storm to seed distrust of GMOs. (Sorry for the seed pun right there). Let's step back and look at RR crop risk.

To be completely forthcoming, the United States has been conducting a large-scale dietary "feeding trial" for about 20 years. RR crops have been widely grown since 1998. And what is the single greatest problem the "food eaters" of our country have? The statistics are pretty clear on this, by the way. Do you know? It is obesity. We have too much food with too high of an energy content. I like what they do in Australia on food labels, they describe how much "energy" the product has, as opposed to how many "calories." I like that. The original fear was that RR crops and their consumption would cause all sorts of problems. Some believed allergies would be widespread amongst our population, for example. There simply is no problem with anyone eating RR crops, compared to any others. If people were going to get sick from them, it would've happened by now. It has not happened, and it is not going to happen. RR crops are safe, and they always will be.

One actual problem of RR crops was that the weed control was so complete that no weeds remained in the treated field. Wildlife and birds (wait, are birds a type of wildlife?) had less weeds that they needed to eat. Thus, their populations may decline when RR crops are used, based on some wildlife studies. To be honest, I really don't care too much about endangered species and there still is food available for those endangered species in the woods etc. But that's just my opinion. Please see the chapter on endangered species for more on this topic.

All the other outcomes of RR crops have to deal with farmers or the companies that sell agrochemicals. They already know what RR crops did, so I'll skip that.

Due to several interacting confounding factors, the end consumer sees no benefit from the use of RR crops, and this is unfortunate. BTW, Europe does not allow broad acre planting of GMO crops. There are several reasons for this, including that European farmers mainly grow wheat

which can be grown with current herbicides. The environmental movement is also much stronger in Europe and not just with regard to pesticides but with many issues. I would offer the opinion to the Europeans that they do not need to worry since we will be happy to sell them food.

We have plenty.

CHAPTER THIRTEEN

"FOOD" IS NOT THE SAME IN EUROPE AND THE US AND THE WORLD

A nine-month supply of crude oil is called a strategic reserve. A three-month supply of grains such as corn is called a surplus.

Let's start with a story. Or two.

I'm sitting in an open air café in Israel. My wife and I are enjoying a wonderful meal with a colleague from the Hebrew University. To be honest, I never got used to eating whole fish, with the eyes still looking up at me. I ate my food, including some bread but did not completely eat all of my meal. My colleague asked if I was done with my meal. I said that I was. He reached over and took the partial piece of bread from my plate. He looked me directly in the eyes and said in a stern voice, "My people starved to death for lack of bread during our war for independence. Bread is sacred in our country." He ate the rest of my bread. For the rest of my trip, I always ate all my bread. I will never forget the story and the passion with which my friend spoke to me.

My daughter was on a two week trip to the Ukraine a few years ago. She told me this story about the family she stayed with while she was there. When the Soviet Union fell apart as a nation, the supply lines including those for food broke down and there were widespread food shortages in the Ukraine. People who lived during that time have a similar mentality as people who lived through other times of food scarcity, like the Great Depression in the United States. So, the adult family members would eat everything on their plate: nothing goes to waste. So, when their daughter was young, she did not want to eat a particular food item, such as a sausage. The daughter would hide the sausages behind the refrigerator rather than eat them. Eventually, the parents found the sausages (microbial activity at work) and said to their daughter, "If you are not going to eat what we give you, you will not eat at all." So, a day or two of sulking and pouting ensued. Then, after a day of this, the daughter ate whatever she had previously not been eating.

Food is not trivial to these people. When you have actually had to go without something, in this case food, you value it more highly. I am uncertain about the original source of this proverb or idea.

After one day without food; a man will ask for food

After two days without food; he will beg for food.

After three days without food; he will steal for food.

After four days without food for himself or his family; a man will kill for food.

We are always five days away from anarchy.

Food is fundamentally different from any other "commodity" we have. Yes, grains and meats are openly traded on "commodity markets" just like steel and gold, etc., but food is different. How groups of people view food is profoundly different around the world, traversing along a huge spectrum of emotions and cares.

I am writing this sitting in first class on a commercial flight from Europe to the United States. For my first meal (There are two on this 8 hour flight.) I declined the appetizer of salmon (not my favorite) and declined the soup (It had coconut in it. I do not like coconut.) So, I instead ate the bread (with softened butter and flavored olive oil) and a nice salad. My three choices of meats were fish, chicken, or beef. I had the chicken, and it was served with rice, snap peas, and carrots in a lovely butter sauce. It was tasty. My four choices for desserts were 1. cheese and bread (The guy next to me got this,) 2. chocolate and hazelnut mousse, 3. vanilla ice cream with small chocolate chunks, really small pieces, inside, (Of course, this was my choice,) and 4. fresh fruit salad. I learned I could have one, two, or all of these desserts (I only had ice cream). I had a glass of milk, two glasses of Coca-Cola to drink, and another glass of water. Oh, and after this I was offered and accepted a lovely piece of chocolate. Very tasty. (By the way, a company bought my ticket and this may be the only time in my life I will fly business class, which is really first-class, on an international flight. It was quite an experience.)

So, food to me (at least on this day) is a luxury item provided to me in the comfort of a seat, with ample quantity and quality to sate my appetite. Today, yes this very day, many people will die from the lack of food. For each person that dies, there are scores more that will lack essential

amounts of energy, protein, and nutrients. Obviously, 99.9% of the remaining humanity lies somewhere along this continuum of food security, whatever that term means. Where are you on this range?

My guess is that if you're reading this (and again, thanks for reading my book)

What? Another piece of chocolate? Why, yes please.

My guess is that you had plenty of food today. Actually, my guess is that you had more food available than you could possibly eat. My guess is that, if you have children, they did not eat all their food, at least not all their vegetables. Truth is, we have plenty of food in America. In fact, from a food standpoint the greatest single problem we have with food is the excess we have that can encourage obesity in much of our population. I promise, that is the last time I will say that.

Food in Europe is more or less widely available. There appears to be a wide spectrum of views, ranging from "only organics" (highest price and very selective) to "enough to survive." In much of Europe, food is an important part of their culture. They eat and drink in a manner that is not rushed or hurried. The evening meal may not begin until eight or nine o'clock in the evening and can easily last two hours. What is the rush? Food is a part of life to savor, to enjoy, to spend time with family and friends.

Contrast this "slow and enjoyable" European view of food with ours in America. Many people enjoy the convenience of fast food, "Do you want fries with that?" I know people who eat "fast food" for breakfast, lunch, and dinner. Have you heard the phrase, "Would you like that supersized?" Pretty much all my siblings are overweight like me, and this may be due to our eating regimen when we were young: consisting of breakfast, lunch, dinner, afterschool snack, supper and finally a bedtime snack. Not too distant from the Hobbits with their first and second breakfast, etc. Use of the trademark name not intended to indicate food security or lack thereof in the Shire or in New Zealand.

So, back in the Organic Myth chapter I shared about the technical reality of organic crop production. The opportunity cost of this approach is acceptable for the moment, but as the population grows, we will need more land to grow food. The truth is, that the "experts" have been saying this for years, and the apparent truth is we still have plenty of food.

At least for today.

CHAPTER FOURTEEN

THE PESTICIDE TREADMILL (COMPARING PESTICIDES TO ANTIBIOTICS)

I think it is safe to say that many, maybe most, Americans want to take the easy way out. Years ago, a well-known actress named Cher was advertising for some sort of exercise regime, as she displayed her well-toned body, she said in the ad "Fitness: if it came in a bottle, everyone would have a great body." I think that sentiment is applicable to some Americans today.

Words mean things and sometimes how we define terms shapes our perceptions.

Diseases caused by bacteria that invade the human body have killed a huge number of humans over time. It has been only in the last few decades that wondrous chemicals have been developed that kill the bacteria inside us but do not kill the bacteria's host organism (the human). Over the eons of time, many people died from a wide range of bacterial infections. So, what did the inventors of these wondrous new chemical treatments call these marvels? Bacteriacides? No. They chose the term antibiotics. That does not sound so bad....

Contrast that with the chemicals used to kill plants a farmer does not want in his crop fields, herbicides, which is a type of a pesticide. To kill insects, you have insecticides; to kill fungal disease organisms, you have fungicides. That does not sound too healthy, does it? I find it interesting that women (or men) do not have fungus infections, they have "yeast" infections (not going down that road any further). Although we can have foot fungus. People have that. Hmm.

Being on the "pesticide treadmill" is an idea that once a farmer starts using chemicals, then that chemical will eventually stop working due to pest resistance, thus the farmer must use a stronger chemical, thus the farmer gets on a treadmill or trap that is no good. You add the use of transgenic GMO varieties and WHAMMO! No hope for any good outcomes from this, for sure.

So, let us consider the "antibiotic treadmill" that we humans are now walking upon.

A young, caring mother of two beautiful children is distraught that her son has an ear infection, or a cold, or any other kind of infection or ailment, really. She takes her child to the doctor, and the doctor reports that the infection is viral in nature, meaning it is caused by a virus and not bacteria. The mother insists that she MUST have some antibiotics to help her son get better. The treatment regimen of "let the body heal itself" is not adequate for her. She wants a pill or shot to make her child feel better now! As someone that has taken the time to explain why the overuse of antibiotics can eventually result in their lack of effectiveness, I can assure you this is a difficult, complex task to get a mother, who genuinely cares for her child, to accept that a pill will simply not work in this particular situation. In a perverted sense of right and wrong, when one of our children was taken to the doctor with a sore throat and fever, we hoped for a positive strep test, since that indicated an obvious course of treatment that would result in our child being better very soon. How sick is a parent to want a child to have strep throat? Well, they were already sick and at least this way we knew best how to treat it. In the absence of a specific causal agent, the doctor was forced to say, "it appears to be viral."

The overuse of antibiotics can select for those strains that are resistant to that treatment. This is one reason why the doctor always tells you to take all the pills, even if you feel better right away. Farmers also have reduced the use of antibiotics on their farms, to hopefully reduce antibiotic resistance. When all the antibiotics stop working, then real health problems can occur.

In recent years, there have been some newly discovered and released modes of action of antibiotics (thank goodness!!). Unfortunately, there have not been such developments in herbicides and farmers do not have the new tools they need to control pests, especially weeds. Some companies are working to discover new active ingredients, but the combination of extremely strict environmental requirements, plus expensive toxicity testing, plus a limited number of years they can sell the product under patent protection have discouraged many companies in this area. Development of new herbicides is even more difficult in Europe, with the politically based registration system more or less precluding any meaningful new herbicide development.

So, why do I not see websites criticizing parents from overusing antibiotics? I see websites that criticize antibiotic use in farm animals, and much of these uses have been reduced in recent years. It used to be, many farmers would add antibiotics to animal feed rations, since their addition caused an increase in animal growth in the apparent absence of any disease. Now, most antibiotics are only used when a disease organism is present (probably a good change).

Why are there no websites against soccer moms and kids on antibiotics? Well, because the moms are intimately familiar with taking pills and their apparent benefit (kids get better, kids feel better) is greater than the risk (most moms think there is no risk or harm). Contrast this with pesticide use on farms. Consumers are not familiar with them and so they see no benefit at all from pesticide use by farmers. The fear of the unknown results in a "fight – send some money to the website or flight – do not use the food grown with those nasty chemicals" response.

It would be hard to imagine any development in the last 100 years that has done more good for humanity than antibiotics. My guess is that the population curve going up like it has is directly related to effective antibiotics being used. Did you know that a person in 1900 could get a scratch from a tree or nail or whatever and develop an infection and die from that infection? Did you know that more soldiers died from diseases in wars prior to WWII than from bullets or artillery shells? No, you did not, and I did not either. Antibiotics are wondrous and fabulous and they are great chemicals.

By and large, humans usually only use antibiotics when they need to do so. I believe farmers are the same in their use of pesticides. My guess is in the decades ahead, as the population grows, we will see crop protection chemicals (too late to rename them, I am afraid) in a similar, although not as bright, a light.

CHAPTER FIFTEEN

CONCLUDING THOUGHTS

Now, a few words about farming in general. These ideas apply to both organic and conventional farmers, and I wanted to share them.

Having at one time been a salesman of seed, fertilizer, and chemicals directly to farmers, and growing up on a farm, and talking to many farmers from all over the world, I have at least a little practical knowledge of farmers and farming. Here are a few of my observations about these wonderful people:

1. Farmers do not want to spend money on pesticides.

2. Farmers like to complain.

3. Farmers want to make money.

4. Farmers are usually good stewards.

Now, let me elaborate on these four ideas.

1. Farmers are generally okay spending money on their trucks, (Who doesn't like a nice truck!) or maybe on seeds. My dad told me growing up the following rule, "When it comes to your seed and your tools, the best is not too good." (Quotation attributed to Fred Mueller circa 1928). Farmers also understand the need to spend money on fertilizer because each harvest removes some nutrients so they realize they must add some back. But pesticide use normally only prevents something from reducing their yield. Pesticide use does not intrinsically increase yield, rather their use only reduces the yield loss. If there were no insects present, fields with no insecticide would yield the same. If there were no plant disease organisms present, no fungicide use results in the same yield. If there were no weeds present, no herbicide would be used and the farmer gets the same yield. Now, to be sure, using pesticides usually results in an increase in net yields, but only if the farmer has a pest problem.

The cost of these chemicals is not too much for the farmers, since they have several good choices (usually, not always). That being said, if farmers could grow a full crop and NOT use any pesticides they would certainly do so. I guarantee it. Farmers do not like to spend money on pesticides, and they only spend money on pesticides when they absolutely must to protect their crops in their fields. I don't remember any NGO's telling you that.

2. I love to listen to farmers complain, and they almost always do. Everything, including pesticides, costs way too much. Crop prices are too low. The weather is too hot, too cold, too dry, too wet. So, if the farmer has a good crop what is his complaint? Answer: where am I going to store all this grain? If the farmer has a good crop and sells at a high price what is his complaint? Now, I'm going to pay too much in taxes! I think you see what I mean.

This part is not directly related farmers complaining, but I wanted to comment on the incredible productive capacity of modern, high input, high-yield farming. These farms and the farmers collectively produce so much grain that the price goes down after a few good years of high prices. We have abundant food, that we can pay for, not because of governmental programs or companies or universities, etc. We have excess food because of our farmers.

Please remember that.

3. Every farmer I know needs to make money. For sure, there are some "show farms" that have agri-tourism, corn mazes, pumpkin patches. etc. There are also farmers who farm as a hobby or as something to do after retirement. But most farmers need to make money to keep farming. Often this can be difficult.

This is an attempt at humor. An ag economist (yes, they have those) was at a meeting of potato farmers. Costs to grow their crops had increased in recent years and the price to sell the potatoes remained the same. One farmer asked this question of the ag economist "On my farm I can grow potatoes for 46 cents per pound, but I can only sell them for 41 cents per pound, so I'm losing five cents per pound. What should I do?" The ag economist response, "get a bigger truck."

If a farmer can make more money growing organic crops, then that is great and sounds good to me. A direct marketing, value-added farm-to-table system is good and wonderful. The "locally grown" movement can be a

good opportunity for some farmers that live near cities and urban centers. No problem with that. That being said, many of our good agricultural soils are located a great distance away from the cities, such as eastern Kansas. There are millions of acres (actually most of them) that cannot prosper on a local market. No doubt the government programs could allow for more crop flexibility and slowly things are changing. Profitable farmers are the bedrock upon which our economy and our very lives depend. I remember seeing the sign on a farm truck:

Know farmers, know food

No farmers, no food.

I think that's a good way to put it.

4. Some farmland is passed from generation to generation. The farm I grew up on and worked in my youth is now farmed by a different family. My Aunt Loretta never married and wasn't the easiest person to visit, confirmed spinster, never met something or someone that she couldn't disagree with. She lived her entire life in the same house on that farm. I would visit her and I would leave my wife and kids talking to Loretta and go for a walk on the dirt farm road. By the way my wife still gets mad when she thinks about how I "abandoned" her and the kids this way.

I would walk up and down the field road and feel a peace and calm that words cannot describe. Anyone who works a piece of land for several years, especially one that's been in the family for generations, can understand this feeling. My feeble words cannot capture, cannot express the depths of this emotional connection to this sense of "this place is special to me." I should not say this, and I apologize in advance for my arrogance, but I pity you that read this and do not have the sense of peace, of purpose, of meaning, of continuity, of eternity. I would guess that for most/many farmers, this is how they feel about their land. It is not only about money, it is about leaving the farm, this farm, my farm, to my children in as good or better shape than when I got it from my parents.

NGOs spewing venom about farmers poisoning their fields with toxic chemicals have no idea of the depth of stewardship, the caring and protecting, the connection to the land of most farmers. Now to be sure, some farmland is owned by corporations or individuals as investments, and they sometimes pursue short-term profits at the expense of soil quality and quantity. There are always some bad operators in any given population. But most farmers, all around the world, have a deep caring for

the land.

"Remember man, that you are dust, and to dust you shall return." Some Christians say this at an Ash Wednesday service each year. Or in The Lion King when Mufasa says to Simba "We become the grass, and the antelope eat the grass, in the great circle of life."

My plans are to be cremated and spread on this field at the home farm, after I die that is. I find comfort in knowing my final resting place will be in this field, on my home farm, as fertilizer for the crops. My dad always told me I was full of shit, which should make me be good fertilizer, but not certified organic.

Thanks for reading.