# INTRODUCTION

## THIS BOOK'S FORMAT

**This book is for current and future operators,** covering background and basics as well as advanced topics, such as the Permabed System, and innovative techniques like the Compost-a-Path Method.

**The holistic discussion** covers principles to help growers adopt and adapt the presented techniques and designs to their own context, rather than having to apply a cookie-cutter plan.

**This illustrated guide** has hand-drawn designs by me, alongside photos, to help bring concepts together. Unless otherwise stated, I took all the photos. There are also full-page infographics (figures) covering the main design concepts.

**The book's jargon** has many terms for innovative two-wheel tractor use. Important terms will be in bold and defined briefly the first time they occur.

**This book is organized** into main topic chapters which are dotted with Pro Tips, Design Boxes, and Farm Features to help the conversation go deeper with case studies and examples.

***Pro Tip***

***Design Box***

***Farm Feature***

## ABOUT THIS BOOK

Despite increasingly widespread *two-wheel tractor* use, agriculture and landscape industries remain *defined* by four-wheel tractors. In part, this book's goal is to return the two-wheel tractor to its rightful place as a small-scale solution for land management, especially for diversified and highly profitable stewardship of farms, homesteads, and landscapes.

**Chapter 1** explores 100 years of two-wheel *tractor origin*, innovation, and renaissance to whet our appetite for broader and more innovative uses. This includes my own evolving experience.

**Chapter 2** discusses this tractor's benefits, types, *essential components*, and operation.

**Chapter 3** examines some *specific equipment* use, accessories, and adjustments.

**Chapter 4** teaches decision-making for scale-suitable equipment using principles of scale, goal setting, equipment design, and enterprise planning. The chapter includes brainstorming exercises to help growers plan for the proper scale at different points in their farm evolution: ***start-up***, ***scale-up***, and ***pro-up*** scale phases.

**Chapter 5** showcases different *enterprise types* with tractor, equipment, and operation recommendations to help growers situate themselves and incorporate the design concepts discussed.

**Chapter 6** outlines the ***Permabed System*** as a longer case study of equipment selection, adjustment, and use. Here innovative techniques, like creating Compost-a-Paths, are detailed for profitable and diversified land use.

**Chapter 7** shows step-by-step equipment tasks to *transition any piece of land* to a garden system.

**Chapter 8** helps growers achieve long-term success with key tips and examples of *tractor maintenance and care*.

**This book wraps up** with an eye to the future of two-wheel tractors, crucial next steps in equipment design, and a call to action for change-makers and the future of food.

## SMALL-SCALE PROFIT RESILIENCE

Hey, have you seen the potential of two-wheel tractors? This piece of equipment is small-plot maneuverable, start-up budget affordable, multi-enterprise functional, and future-need adaptable. Two-wheelers are increasingly being used by intensive market growers and homesteads, but what about using them in landscaping, orchards, and edible ecosystems? Two-wheel tractors are for *all* small-scale, highly productive, and **profit-resilient** land management! And by profitable, I mean in both the short- and long-term because they can be investments in soil, ecosystem services, biodiversity, and social capital. Enterprises that employ two-wheelers tend to be *profitable* (more income than expense) and *resilient* (nimble for socio-economic and environmental change).

**Small-scale** is often associated with *acreage-scale*. Fifty acres of mixed land use is small compared to 1,000 acres in wheat, but a 3-acre market garden or ¼-acre urban farm is even smaller! Small-scale also means *equipment-scale*; the equipment you use is part of defining the scale of your operation. Growers who can manage their land with only hand tools and/or two-wheel tractors have a smaller equipment-scale than those using primarily four-wheel tractors. Yet, small-scale doesn't mean lower profit or productivity! Profitable land management often contradicts "bigger is better"; intensive growers can make more income per acre with less land and equipment. However, larger-scale growers can also be quite profitable when efficiencies of mechanization and the ability to meet more needs in situ (such as growing your own mulch, fertility, etc.) become real savings and offer new profit centers. Resilience is usually achieved with a balance of scale; your acreage-scale and equipment-scale should be in harmony to suit a business and management model for your land.

Finding a profitable niche for your land, goals, and enterprises is helped by balancing **holistic scale principles** (see Figure 1), giving insight for *decision-making* no matter what your acreage, equipment, or production is. There is no stark boundary between large and small-scale success, and a shift in one principle, like actual production acreage, will change others: labor dynamics, equipment, or profit potential. For instance, a farm with sloping

topography will be better managed with a method suited to that terrain. This will affect equipment and other aspects of scale, helping the farm meet its goals and achieve *steady-state profitable management* at a **static scale**. Your static scale is the intended goal of your operation's scale—that maximum of acreage, equipment, and other principles. Once your intended acreage is reached, for instance, you shouldn't acquire more land. You are at your static scale, and you can now operate and improve practices within steady-state management rhythms without further expansion.

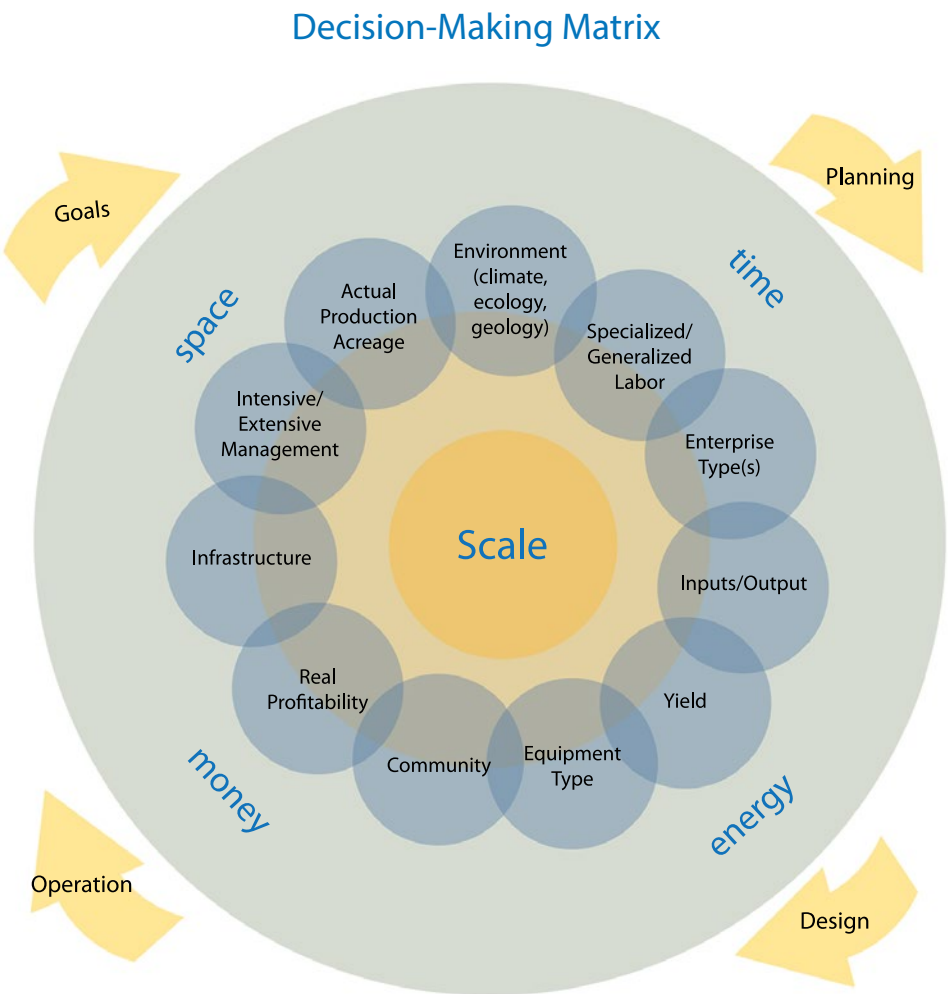
That being said, two-wheel tractors and associated high-production methods are *usually* most suited to growing areas of ¼ acre (intensive urban gardens) to 1 acre (typical market gardens) but can be used for areas up to 6 to 13 acres (ex: agro-forestry). As such, this book discusses different tractor users with examples of the acreage, equipment, and production scales they might use.

*This farm is making use of small fields using scale-suitable equipment.*

***Pro Tip:*** *Equipment decision-making is important because short- and long-term equipment selection is a major way that growers can make either the biggest mistakes or have the greatest successes. Having the right equipment can revolutionize your homestead or farm. The wrong equipment choice can dictate how you grow instead of facilitating how you want to grow.*

## FIGURE 1: HOLISTIC PRINCIPLES OF SCALE

Holistic principles of scale are a shifting ratio of land investment and management. They form a decision-making matrix for growers to use to set goals, make plans, create designs, and run their operations. A growers goal should be a steady-state profit resilient land management at an intended scale.




*Decision-making is anchored in scale principles. These shift with space, time, energy, and the amount of money invested by growers.*

**Keep this matrix in mind** and refer to it throughout the book and as you plan over the years to come.

# Chapter 1
# A Story About a Horse

The two-wheel tractor has come in and out of popular use for over 100 years. Its long history is similar to my own shortened history through the many stages of my agrarian business evolution. Let's explore the history of two-wheel tractors and my own connection to this small but mighty piece of equipment.

***"If you can't ride, can you fall?" (said the Horse)***
***"I suppose anyone can fall," (said the Boy)***
***"I mean can you fall and get up again without crying and mount again and fall again and yet not be afraid of falling?"***

— C.S. Lewis, *The Horse and His Boy*

## THE HORSE AND HIS BOY

I remember seeing that 10-horsepower "Italian Stallion" (as we fondly referred to that blue Italian-made, two-wheel tractor) for the first time one summer when I was about twelve. I was reading a book by C.S. Lewis under an apricot tree watching the Stallion open new ground for a three-sisters planting at our homestead in New Mexico. Like most kids, I was attracted to equipment, and this was a pretty neat machine! It had different attachments, looked like a little race car, and had the power to move earth in amazing ways. "Small but mighty," I thought.

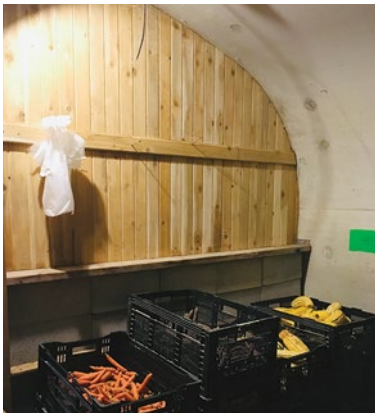
What I liked most were the green rows of squash, salad, and peppers that grew in the tidy beds that the tractor formed. We were just one street inside the city limits, so the small stature of the Stallion was scale-suitable for our homestead—a property that was a back-to-the-land paradise, with gardens, orchards, greenhouses, small livestock, and more. My dad, an early permaculture adopter and designer, had been working part-time on our edible

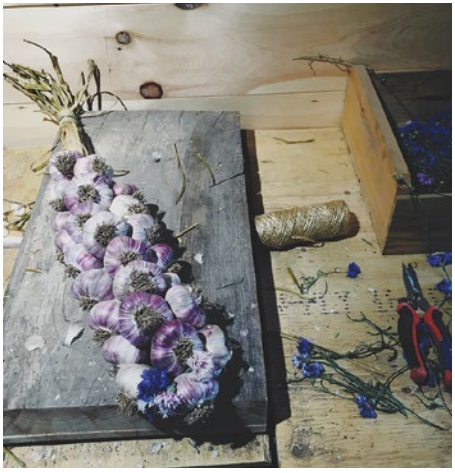
yards between landscaping and teaching jobs, and we kids would often tag along to help.

The Stallion was also great for the mountain farms in northern New Mexico that quickly adopted small-scale solutions for organic production in narrow agrarian valleys with *acequias* (traditional irrigation ditches that carry mountain stream water into the farm plots). One of these was a cooperative farm my brother and his friends started. The time I spent there in garden plots that followed coyote-willow streams has left lasting memories: the taste of pinyon nuts, the smell of Ponderosa pine, the colors of sage, and the feel of a cold-water creek—along with the jingle of the "pirate's gold," those half dollar coins Dad kept in his pocket as a reward for fully submersing ourselves. Yet, it was heirloom squash harvests, fresh potting soil, warm hoop houses, and the feel of steel turning soil that captured my heart and made me a lifelong gardener, homesteader, and farmer. "Small is beautiful," according to E.F. Schumacher, whose books I leafed through between landscape jobs.

When I started my own market garden in Ontario (where acequias ran as large as the Ottawa River), I used two-wheel tractor power to grow a rich variety of food. As the farm scaled-up over time, I integrated four-wheel tractors as part of what became a 10-acre permaculture market garden growing crops, cover crops, berries, herbs, and fruits for Community Supported Agriculture (CSA), farmers markets, and on-farm events. I still used the two-wheel tractor. It has had continued use for specialized jobs in greenhouses and the 100 ft caterpillar tunnels used for heat-loving tomatoes, peppers, eggplant, basil, and other high-value crops.

Now that my farm has transitioned production to become an edibleplant nursery supplying transplants for my company, **Edible Eco-system Design**, the two-wheel tractor has renewed importance. It has revolutionized my ability to maintain diverse edible plants efficiently and hit the ground running on an edible landscape installation! My dedication to *small is mightily beautiful* continues through research and education as part of **The Ecosystem Solution Institute**. I haven't forgotten about the horse and his boy as I prepare new food-forest beds.





Above and left: *Shown here are designs that won three Agri-innovation awards for the solar-powered farm, Permabed System, and a geothermal and ice-cooled cold storage/root cellar. These were used to farm organic vegetables and fruits, heirloom seed garlic, and specialty winter crops.*

Right: *Two-wheel tractors are a critical part of the edible plant nursery and ecosystem landscaping. Here we are making new beds for a tree nursery from scratch. Learn more at www.zachloeks.com*

***Pro Tip:*** *Two-wheel tractors are great for landscaping because they can work in tight spaces, accommodate versatile implements, and can fit (with implements) in a small 6' x 12' trailer for easy transport to jobs.*

*The farm has expanded to include numerous satellite projects, which together form The Ecosystem Solution Institute, an organization dedicated to education, propagation, and inspiration that was formed to encourage edible diversity and solutions for growers at all scales. A 100-acre Edible Biodiversity Conservation Area is currently under construction where thousands of edible plants are being trialed and designed into practical guilds for farmers and home gardeners. Learn more at www.ecosystemsolutioninstitute.com*

## THE ORIGIN OF TWO-WHEEL TRACTORS

Need is the mother of innovation, and the first two-wheel tractor emerged in the early 20th century as farms sought new equipment solutions for growing needs. This innovation was a new mechanized option for farmers who primarily used horsepower. The design was a multi-functional, self-propelled machine guided by a walking operator or one who sat atop the implement. These early implements were the draft type, actually modified from horse farming. Interestingly, in the 21st century, modern farms that use actual horse power and growers using two-wheel tractors operate on similar scales.

The transition from horse power included steam-powered tractors before gas and diesel became the main fuel. But whether steam, gas, or diesel were used, the difference between four-wheels and two-wheels was less distinct than it is today. In fact, the two-wheels or four-wheels were simply replacing the popular two-horse or four-horse configuration used by early farmers. They were just variants of the same innovation: the tractor. This is in stark contrast to how two-wheel tractors are seen today—as *less than* a tractor.

The Detroit Tractor.

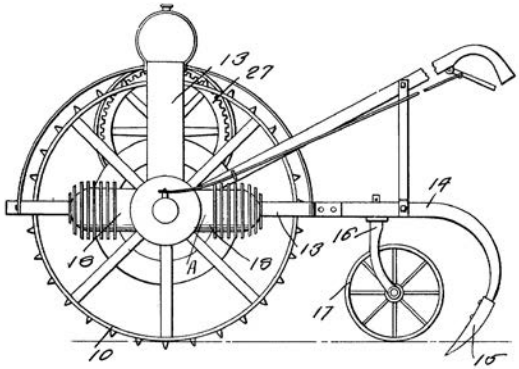
Showing how it may be employed for the purpose of hauling a wagon, mower, seeder, grain binder, etc. In every instance rein steering is used. A pull on either the right or left rein connecting the engine by a special friction clutch to the steering gear and the tractor is turned by the engine's power.

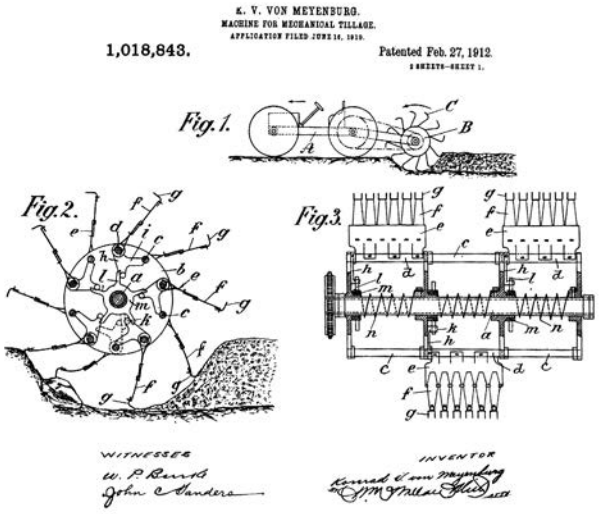
The Detroit Tractor.

Showing how the sulky wheels are attached when the tractor is not pulling anything. By means of the rein steering, a slight pull is all that is necessary to make a complete turn. A simultaneous pull on both reins stops the tractor. The third rein is used only to shift the gears from neutral to forward or back.

*In 1913, the Detroit Tractor Company introduced a "rein-driven tractor" reminiscent of early horse farming. Modern horse farming remains a good parallel for two-wheel tractor operations, which can handle a similar scale of operation.* PHOTO SOURCE: DETROIT TRACTOR COMPANY, *AUTOMOBILE TRADE JOURNAL*, JULY 1913.

Despite a century of continued two-wheel innovation, this tractor is all but forgotten on commercial farms. The four-wheel tractor spurred ahead as the powerful solution for the increasing farm size in America. Single-purpose power tools and small four-wheel machines became prevalent in property and landscape management as the two-wheel tractor was almost lost to sight. However, two-wheel tractors persisted where small land-holdings remained and intensive agriculture was valued. One such place, Italy, was and still is a hotbed of two-wheel tractor innovation.






*Early implements for two-wheel tractors included plows, cultivators, carts, and a new innovation: the rototiller. It was first patented by Konrad von Meyenburg in 1912 as a "Machine for Mechanical Tillage." In 1916, Benjamin Franklin Gravely innovated with his "Motor-Plow," which included an auxiliary motorcycle engine to help power a single-axle, single-wheel cultivator; he went on to be one of the lead innovators in American two-wheel tractor manufacturing.* Photo Credit: B.F. Gravely, Jr., Motor Plow, US Patent 1,207,539, Dec. 15, 1916. and Konrad von Meyenburg, Machine for Mechanical Tillage, US Patent 1,016,843, Feb. 27, 1912.

## HONORING THE TWO-WHEEL TRACTOR

Let's honor the two-wheel tractor as being a tractor in its own right. Equipment should be scale-suitable, and four wheels isn't synonymous with farming. The most important trend in agriculture today is arguably the pivot toward small-scale growing where small farming, permaculture, and ecosystem design will continue to be leaders in mitigating climate change and improving food security, safety, and sovereignty while enhancing local profitability.

## THE ITALIAN TWO-WHEEL RENAISSANCE

In Europe, small fields are common. The farmland has been divided into smaller and smaller chunks over thousands of years. Walking the fields from Liguria down to Sicily, one can see that expansion was not as straightforward as it was on the great plains of North America, and perhaps that is a good thing. Need *does* bring innovation, and small *is* beautiful! In these small plots, the two-wheel tractor continued to be a practical piece of commercial farming equipment. Indeed, in Italy, the second half of the 20th century saw an expansion of two-wheel tractor use and innovation, which was then fed *back* to America. This all piqued my curiosity and sent me back to the source to see why two-wheel tractors had such a strong presence in Italy.

The country of Italy is shaped like a foot pressing down into the Mediterranean. Some people see it as a stylish Milanese shoe; sports fans see a cleat kicking a Sicilian soccer ball. But when you take into account that almost the entire breadth of the country is mountains covered by small-scale farms, it starts to feel more like a work boot! And work they did, in a land where a rich history spans prehistoric, Etruscan, Roman, and Italian cultures.


Image credit: iStock-1213581408, Peter Hermes Furian.

The food culture of Italy is as diverse as the microclimates in those hills and mountains. One can find small fruit and vegetable greenhouses in the northern Dolomite mountains, hazelnut orchards in eastern Piedmont, and cliff-clinging homesteads and farms throughout the Ligurian Hills, including the famous basil terraces near Genoa. There are tomatoes, grapes, and apricots growing in deep soils in Campania under the watchful eye of Vesuvius and truffle-dotted woodland hills in Toscano amidst the great vineyards of Chianti. From Sicily to Sardinia and Naples to Genoa, the land is all mountains. Save, one area!

There are great open farmlands full of vegetables, rice, and grains in the northern provinces of Lombardy, Emilia-Romagna, and Veneto. These large, open fields are one of the points where mechanization emerged in Italy at the turn

of the 20th century, and it was here that the two-wheel tractor became an essential part of Italian farming. Yet, it was the rest of the provinces, with their immense hilly terrain and small fields, where the two-wheel tractor remained most relevant.

*Here, in the Italian Dolomites, the two-wheel tractor is scale-suitable to small brassica and radicchio fields and narrow high tunnels growing tomatoes and salad. The diversity of food at an Italian farmers market is staggering. The land and its micro-climates allow a plethora of productions, and the people know how to cook and enjoy this diversity. This all supports the small-farm growth that is returning to the Italian countryside, reinvigorated by the new food revolution! This new revolution includes a return to living off the land, growing food for local and regional markets, and reinvesting in scale-appropriate technology innovation.*

FARM FEATURE

## THE CASTOLDI STORY

Cesare Castoldi grew up on a dairy farm near Abbiategrasso, Italy. Like most early 20th-century farms, they had gardens, hay, and orchards. Cesare was one of four children—all boys. Back then it was a long horse carriage journey to town, so the children spent their days on the farm playing and doing chores by hand—but young Cesare had an eye to the future!

One day, a traveling salesman stopped at the farm and remarked that the boys were of the right age and that "not far from here, only 20 km, there is a family with five girls. You are all nice and well-educated," he said, with a match-making smile. Cesare and Adele began to court, and they were happy and did marry in 1895. Their third child was named Luigi Castoldi, who became a key contributor to the small-farm revolution we have today, though he didn't know it then, and it would take many years and many innovations to make it happen.

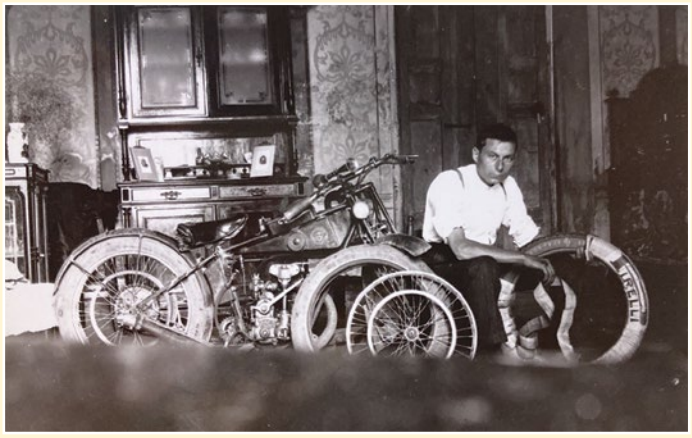
Cesare and Adele were a smart match, and she was a very smart lady. Cesare was now running the fields of the family farm, and Adele managed the business. In 1929, just before the Great Depression, she proposed that they withdraw all their savings from the bank to buy another big farm. When the stock market collapse came, the effect on the Castoldi farm was lessened because they had put their earnings into land. This kept their dreams alive alongside the aspirations of their children.

Young Luigi Castoldi had a "strong attitude for the design of machines," his son Fabrizio remarked many years later, and Luigi's brother Achille also loved mechanics and sports. Achille went on to win gold as an Olympic rower in Warsaw, Poland. When the family went to the farmers market, everyone congratulated Cesare on his family's sporting and academic achievements. Little did he know that a unique family enterprise was developing.

Cesare was an early adopter of technology, including a recently imported Fordson tractor. So, in celebration of the gold medal, he bought Achille a modern mechanical wonder: a motorcycle! Achille was proud of his motorcycle, a local first, and he drove it everywhere, startling people and horses alike (none of whom had ever *heard* of one before). Luigi asked constantly if he could drive his older brother's motorcycle. Achille said, "No!" But Luigi wasn't one to give up easily, and when he was refused for the umpteenth time, he asked Achille if he could simply *clean* it. Achille agreed.

The excuse to clean the motorcycle granted, what Luigi *actually* did was disassemble it completely in the living room (with his younger brother Aldo polishing each and every component). To put it mildly, Luigi was extremely fond of the inner workings of machines.

By 1930, Achille had placed on the podium in 70 races, and he was getting too old for rowing. He still loved water sports and decided to try motorboat racing and wanted to enter with a bang. So he talked with his brother Luigi about an idea. At the time, the popular Johnson speedboat engines



*Luigi cleaning his brother's motorcycle—as described by his son, Fabrizio Castoldi—who sketched out for me some of the early innovations his father made that led to the founding of a two-wheel tractor company.*
Image Credits: Courtesy of the Castoldi Family and BCS

(300cc and 500cc) were American-made and often suffered malfunctions as a result of being transported across the ocean. The European engines were not powerful enough to compete in these races, so the Castoldi brothers needed a solution that would allow the use of Italian engines that would also give them a competitive edge.

So, Luigi told his brother, "We need to work on this!" Then, with cousin Mario, a designer of early water-landing planes, they sketched out a new race boat for Achille. Luigi and Mario's design, built by local boat builders, was narrow, with two outrunner wings and triangle-fabrications underneath. When the boat reached speed, the hull would rise, lifted by the wings, leaving only three points of the hull touching the water. With this early hydroplane solution, Achille started racing and won a world record on the channel outside of Milan. In the next race, on the same day, he won another world title. Two world records in one day. This is a story of engineers and an athlete!

Luigi had been studying engineering in 1924 in Turin, but when he took a break and returned to farm with his father, he stayed for six years. It was during this period the speed boat was innovated, reinvigorating his interest and spurring him to finish his degree. Luigi started turning his engineer's mind toward many agriculture projects, including helping to develop a micro-hydro project for a local farm's electrical lighting.

Then, knowing well the arduous work of cutting hay by scythe, Luigi innovated a hay mowing machine. In 1940, his prototype was built in the horse stables on the family farm and released for

sale in 1942. The horses looked at him askance. Luigi had begun a journey developing a new form of *horse power* for local farms! Today, Luigi's innovations live on and "Castoldi" is the "C" in BCS, the popular two-wheel tractor company that makes the tractors found today in market gardens, and on homesteads and farms—and the *Italian Stallion* on our own small-scale farm in New Mexico.

*Engineer Luigi Castoldi personally tests his invention in 1942: the* new Motofalciatrice *243.*
Photo Credit: Fabrizio Castoldi

## AMERICAN RETURN TO SMALL FARMING

In America, the two-wheel tractor has been picked up again by growers whose success from *direct marketing* makes small-scale farming profitable. For 50 years, the market gardening revolution and a back-to-the-land movement has adopted two-wheel tractors as their equipment-scale.

There are more than just Italian influences on the new food revolution in North America. Traditional French market gardening and Japanese **Teikei** met forward-thinking Northeastern growers like Eliot Coleman, who innovated techniques and tools for market gardening and started farming in the

1960s, and Robyn Van En, who started the first **Community Supported Agriculture (CSA)** farm in 1985. Books by both those innovators were important for me as I started up my own market garden and CSA. At the same time, Indigenous Australian knowledge was melding with ecological science into a new design methodology called **Permaculture**, which was emerging in the 1970s due to innovative thinkers like Bill Mollison and David Holmgren, who were finding fertile ground in techniques that encouraged a more regenerative society and agriculture. Permaculture caught on quickly in the Western states; one of the hot spots was New Mexico, where my dad was a designer in the 80s and 90s.

These movements and pioneers helped adopt and adapt small-farming to the modern context. Two-wheel tractors became the equipment of choice for a new wave of organic growers at the end of the 20th century. This pace has only increased with the turn of the 21st century. I started my market garden in 2007, purchasing a BCS 853, which had great improvements and additional features compared to the 725 I grew up with.

### THANKS GIVING

Scale-suitable tools, techniques, and equipment are essential to land profitability and resilience. Ideas have been shared across oceans, from ancestral lineages, and always with an eye for reinvigorating innovations in new contexts. Let's give thanks to all early food innovators, and primarily the Indigenous peoples of the world who tended the first soils upon which our ideas and innovations grow.