**How to Address Drought? Start with the Soil!**

*Healthy Soils Article #1*

Water is life. It's a simple phrase, yet few people truly think about it. We drink it. We use it to grow our food, to clean ourselves, to flush wastewater, and to generate electricity. The World Economic Forum has declared that water "is a unique resource that underpins all drivers of growth – be it agricultural production, energy generation, industry, or manufacturing."[1]

But with almost 8 billion people on the planet, our freshwater resources are increasingly strained. And that's before we factor in climate change. As temperatures have warmed over the past century, the prevalence and duration of drought has increased in the western United States.[2] In 2011, Texas had the driest year since 1895, which led to an estimated $8.7 billion in agriculture-related losses.[3] Droughts and heat waves each can individually cause significant adverse impacts; and when they occur together, the effects are even more devastating.[4] A recent study concluded that the frequency of compound dry and hot extremes has increased substantially in the past decades, with an "alarming increase" in dry-hot extremes.[5]

Climate models unanimously project increased drought in the Southwest, which is considered one of the more sensitive regions in the entire world for increased risk of drought caused by climate change.[6] The 2017 Texas State Water Plan estimates that Texas could have a statewide water shortage that would cost $151 billion in estimated economic losses by the year 2070.[7] If no additional water supplies are developed, water users face a potential water shortage of 4.8 million acre-feet per year in 2020 and 8.9 million acre-feet per year in 2070 in the event of a repeat of the drought of record.[8]

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[1] World Economic Forum. Global Water Initiative. Available at https://www.weforum.org/projects/global-water-initiative

[2] Andreadis and Lettenmaier. *Trends in 20th century drought over the continental United States.* Geophysical Research Letters, 33.10. (2006). Available at https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2006GL025711

[3] DeDe Jones, Dr. Steve Amosson, and Gid Mayfield. *State Drought Losses Have Significant Impact on Overall Economy.* Available at https://agecoext.tamu.edu/wp-content/uploads/2013/07/RecentDrought.pdf

[4] B. Mueller and S. I. Seneviratne. *Hot days induced by precipitation deficits at the global scale*. Proc. Natl. Acad. Sci. U.S.A. 109, 12398–12403 (2012). M. Leonard et al. *A compound event framework for understanding extreme impacts*. Wiley Interdiscip. Rev. Clim. Change 5, 113–128 (2014). Available at https://www.pnas.org/content/109/31/12398

[5] Mohammad Reza Alizadeh et al. *A century of observations reveals increasing likelihood of continental-scale compound dry-hot extremes.* Science Advances Vol. 6 No. 39 (Sept 2020). Available at https://advances.sciencemag.org/content/6/39/eaaz4571

[6] Sheffield, Justin, and Eric F. Wood. *Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations.* Climate Dynamics 31.1 (2008): 79–105. Available at https://iri.columbia.edu/~blyon/REFERENCES/P32.pdf

[7] Texas Water Development Board, *2017 State Water Plan*. Available at: https://www.twdb.texas.gov/waterplanning/swp/2017/doc/SWP17-Water-for-Texas.pdf?d=5014.785000006668 (page 3)

[8] Texas Water Development Board, *2017 State Water Plan*. Available at: https://www.twdb.texas.gov/waterplanning/swp/2017/doc/SWP17-Water-for-Texas.pdf?d=5014.785000006668 (page 77)

Agriculture plays a dual role in the water crisis. Currently, the agricultural sector uses almost 70 percent of global water.[9] Water is needed to grow food for human consumption. Yet, as a major water user, agriculture competes for water that could be used for drinking and other basic needs as well. Reducing the demand for irrigation would free up more water for other uses, while still providing the basic necessity of food.

Yet how to do so? Many in government, academia, and business have touted genetically engineered crops as the road to a water-smart agricultural future. But despite decades of expensive research and supposed breakthroughs in identifying the genes for drought tolerance,[10] so far this has borne no fruit. Greater success has been made through regular hybridization, as well as improvements in irrigation technology – yet these are far from enough.

A better, more cost-effective solution exists: healthy soils.

Before we discuss how healthy soils can address our water crisis, first we have to discuss what that term means. Healthy soil is soil with a complex community of microorganisms -- bacteria, fungi, algae, protozoa, nematodes, and other tiny creatures. These microorganisms, which make up a significant portion of what is termed "organic matter," enhance the soil's capacity to function as a biological system. This in turn improves the soil structure and water- and nutrient-holding capacity. Practices such as managed grazing to allow pasture recovery, keeping the soil covered with organic matter, minimizing soil disturbances on cropland through no-till or minimal tillage practices, and minimizing the use of synthetic chemicals, all contribute to healthy soils.

So, what do healthy soils offer for our water crisis? Put simply, healthy soils act as a sponge, easily capturing water during rainfalls and storing it for slow release as needed. By holding on to the water, healthy soils reduce irrigation demand, improve drought resilience, and mitigate downstream flooding.

The USDA Natural Resource Conservation Service videoed a simple experiment in which they measured how long it takes for a given amount of water to infiltrate the ground. It took 31 minutes for tilled cropland to soak up the water. Conventionally grazed pastures took only 7 minutes – showing the significant advantage of not tilling. But rotationally grazed pasture was able to absorb the water in just 10 *seconds*.[11]

Consider what sort of difference that rate of water absorption makes when an area is drenched with torrential rains, which would create erosion and flooding on the tilled cropland – but be soaked up by the healthy soils of rotationally grazed pastures. Or what it means in the midst of a drought, when every drop of water is desperately needed.

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[9] Statistics: Graphs and Maps. UN Water. (2012) Available at https://www.unwater.org/water-facts/water-food-and-energy/

[10] Josh Gabbatiss, *Scientists aim to develop drought-resistant crops using genetic engineering.* Science (Dec. 4, 2017) https://www.independent.co.uk/news/science/drought-resistant-crops-plants-genetic-engineering-a8091816.html

[11] https://www.youtube.com/watch?v=IqB4z7lGzsg&feature=youtu.be

Of the farmers and ranchers across Texas who are already implementing soil health practices, one of the best documented, in terms of the impacts on water, is the Bamberger Ranch. When it was purchased in 1969, there were no permanent water sources on the 5,500 acre ranch. Multiple attempts to drill wells 500 feet deep resulted in no water. As a result of a combination of brush removal, the replanting of native grasses, and adaptive grazing management, there are now multiple stock tanks, flowing creeks, and 11 permanent artesian springs on the property. The major spring produces an average of 3 gallons per minute and furnishes all the water used for agriculture, three households, and an education center. Overflow from this spring along with other smaller springs and seeps produce the headwaters of Miller Creek which flows into the Pedernales River, which then flows into the Colorado River, the surface supply for the City of Austin 60 miles away. (http://bambergerranch.org/our-story)

The long-term impacts of healthy soil practices are also evident in The Farming Systems Trial at Rodale Institute, America's longest running, side-by-side comparison of organic and conventional chemical agriculture. Their 30-year report found that the water volumes percolating through soil were 15-20% higher in the organic systems than the conventional system. "Rather than running off the surface and taking soil with it, rainwater recharges our groundwater reserves in the organic system, leaving soil in the fields where it belongs."[12] Given that, it is not surprising that the field trials show that organic crops have higher yields, up to 40% greater, than conventional in drought years.

The potential for improvement in Texas is significant. The NRCS has said that every one percent increase in organic matter results in as much as 25,000 gallons of available soil water per acre. There are 126.5 million acres in agricultural production in Texas.[13] If the land was managed to produce healthy soils – just enough for a one percent increase in organic matter – that land could provide as much as 3.1 **trillion** gallons of additional stored water. Since a significant portion of Texas agricultural lands are low in organic matter and our state has the greatest acreage of degraded rangelands in the country,[14] there are millions of acres that could feasibly see increases of *several* percentage points in organic matter with good management over time.

Given all this, why isn't there more discussion about healthy soils, both in academia and in government? Why aren't more farmers and ranchers implementing healthy soils practices in their management systems? The answer is actually a complex mix of money, power, and human psychology, which we'll delve into in a future article in this series. Stay tuned!

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[12] https://mk0rodaleinstitydwux.kinstacdn.com/wp-content/uploads/fst-30-year-report.pdf
[13] https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=TEXAS
[14] USDA Rangelands Resource Assessment, October 2010. Available at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?&cid=stelprdb1041620