REGENERATION FOR THE NEXT GENERATION

Released October 2021

A research-backed paper by youth leaders of the Heirs To Our Oceans' initiative RAISE: Regenerative Agriculture and Indigenous Systems for our Environment offering a path forward to achieve a better world.

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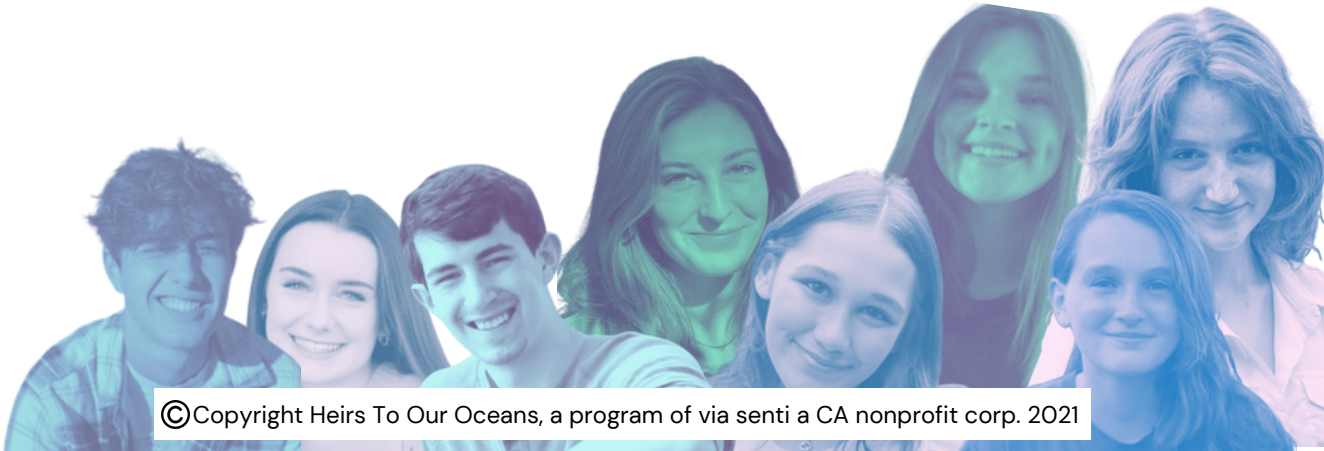


PREFACE

We need basics for our survival, as do our children and our children's children.

The essential natural resources future generations will have available to them -- or even our generation -- are not assured. Factors include the dirt we walk upon and the way we grow food.

Youth everywhere have been impacted by **degenerative agricultural practices** that are harmful to our essential ecosystems and to our health. Communities on the front lines are suffering from water pollution, water shortage, food insecurity, and even forced child marriage and child prostitution.

This paper is written as a plea by the youth of the H2OO RAISE initiative who reside in the United States. It was contributed to and reviewed by experts including scientists and Indigenous Persons who hold scientific, traditional, ecological knowledge.

Through our commitment to research and investigation, we have come to understand the role agricultural practices have in the health of humanity.

We prepared this paper to explain the problems of degenerative agricultural practices, why healthy soil is critical to the health of us and our planet, what comprehensive solutions exist, and why we need to change now.

We are happy to share more about who we are and why we do what we do...

At the heart of
Heirs To Our Oceans
is youth education, empowerment and connection in purpose.

Heirs To Our Oceans (H2OO) is a youth-led nonprofit working to empower ourselves and each other as the next generation of leaders who connect the dots between human and environmental health, inextricably linked environmental crises and humanitarian crises, and citizen science and activism, and we connect with each other to build a global network of passionate, powerful young people striving to realize a better world.

Our **mission** is to inspire the next generation of leaders by connecting them in purpose, educating them on environmental and humanitarian global challenges, supporting them in processing and realizing solutions, and cultivating necessary skills to make real-world change and also adapt to the world they are inheriting.

We have a **vision** where all youth understand the world they are inheriting and are capable of creating a healthier, safer world for ourselves and future generations.

Rivers, lakes, oceans, streams, drinking water - all water on Earth is connected as are we. All youth should understand every aspect of protecting the lifeblood of our planet and the importance of caring for each other in doing so. That is what H2OO is committed to.

RAISE Regenerative Agriculture and Indigenous Systems for our Environment

an H2OO youth-led initiative

Youth of H2OO located in the US formed the **RAISE initiative -- Regenerative Agriculture and Indigenous Systems for our Environment.** Alarmed by the harms of industrialized agricultural practices here in the US and around the world, a team of H2OO youth connected in purpose to address the problem and work to realize a better, safer, healthier future.

H2OO's RAISE has developed a team of strong, critical-thinking young leaders who are concerned about the impacts of the climate crisis, food insecurity, and water pollution, shortage and accessibility.

Youth leaders at Heirs To Our Oceans' Summit for Empowerment Action and Leadership (SEAL) 2018 plant trees near Lake Ngardok in Palau.

Our work focuses on the connectivity between how we grow our food affecting our health, the health of society and humanity, the health of our ocean, the health of our waterways, and all life on Planet Earth.

From the San Francisco Bay Area to Uganda, youth leaders are rising up to seek traditional, regenerative food-growing practices to protect our life sources and each other and to curb the impact of climate change.

We youth leaders of RAISE en**vision** a world where the climate is safe, our ocean ecosystems and waterways are healthy, whole food is in abundance and accessible to all, and people are connected to the land, living harmoniously with nature, utilizing sustainable and ethical agricultural practices.

The RAISE **mission** is to (1) **engage with community stakeholders in educating others** of the benefits of using traditional ways and indigenous systems in growing food and stopping industrialized agricultural practices, (2) **build a movement and develop youth connections** nationally and globally in purpose, and (3) **seek policy change** mandating, without delay, shifting away from harmful and ineffective food growing methods to achieve a healthy and safe future for our generation and future generations.

THE AUTHORS

Meet the 2020-2021 H2OO RAISE team members who prepared this paper.

Dakota Peebler, age 16, residing in California and Co-Chair of RAISE August 2020 to present, contributed to this paper through research, writing, editing and graphic design.

Aislinn Clark, age 16, residing in California and Co-Chair of RAISE August 2020 to June 2021, contributed to this paper through research, writing, editing and graphic design.

Jeremiah Cutright, age 21 and residing in Pennsylvania, contributed to this paper through research, writing and participating in the final editing.

Shay Barton, age 17 and residing in California, contributed to this paper through research, writing and participating in the final editing.

Brigette Ramirez, age 17, residing in California and Co-Chair of RAISE as of October 2021, contributed to this paper through research and writing.

Chloe McKenna, age 20 and residing in Florida, contributed to this paper through research and writing.

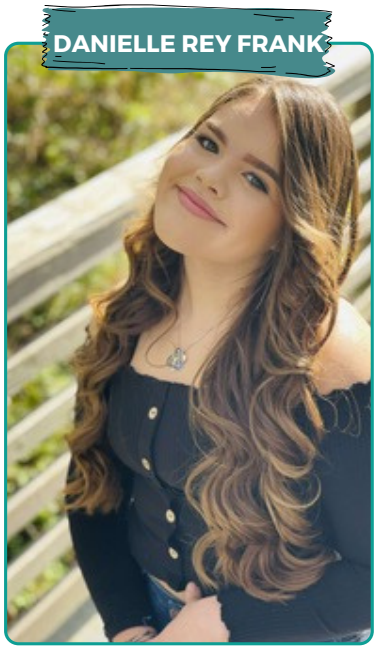
Paulo Lepoutre, age 17 and French-Peru citizen residing in California, contributed to this paper through research and writing.

Camille Kay, age 17 and residing in California, contributed to this paper through research and writing.

Youth leaders at Heirs To Our Oceans' Summit for Empowerment Action and Leadership (SEAL) 2021 learned about traditional agroforestry at One Village Project Farm in Hawai'i.

WORDS FROM YOUTH AROUND THE WORLD

Youth around the world are aware of and experiencing the effects of industrialized agricultural practices. In modern-day "California", indigenous communities have been experiencing consequences of degenerative practices directly.



Danielle Rey Frank, a high school senior from Hoopa, California, and member of the Hupa tribe, shares her experience as an indigenous youth who suffers loss of culture and food security due to dams and water diversion for conventional agriculture.

"For longer than I have been alive my people have been fighting dams that are poisoning the sacred life in our river. The fight is still going on today, alongside the many other grievances we are facing. For example, more water is diverted from our river than we have to spare, this results in our fish dying and the very heart of our valley being poisonous to the touch, my people have fought for water issues as long as they've been around, and now it's my turn... I want my children and their children to know my home the way my great grandmother knew it and the way I know and love with raging rivers and creeks running through the heart of the valley like veins and our cultural needs still being met." [1]

Danielle's vision for the future of agriculture is where practices allow the natural world to return to a state that is healthy for all and where people treat the earth the way it treats us, providing what is necessary to thrive.

Latifah Nansubuga, an 18-year-old youth activist in Uganda, has been a leader in her community since she started a program called Climate Smart Urban Farming (CSUF). Her CSUF program sustainably grows food for her community and teaches other girls how to take agency for their futures. She has provided a source of empowerment and security for young girls who otherwise may have fallen victim to forced child marriage due to famine, as she nearly did, and also acts as an urban solution in tackling food scarcity.

"I am taking action on the issue of food insecurity since hunger and starvation are forcing many people in Uganda into unwanted marriages. I decided to use the things that pollute my environment, such as plastics, old car tires, and containers, to grow food in to solve the issue of food insecurities in my impoverished and polluted community and bring about climate justice." [2]

Kainoa Azama, a 19-year-old Hawaiian youth, shares his concerns:

"There needs to become a realization that all places and regions have a human capacity limit. I know people do not like to hear it, but we have to realize at some point our supplies are limited, and āina [Hawaiian meaning "that which feeds"] can only feed to a certain extent." [3]

Stah Poutai, a Māori youth from New Zealand, shares how her community has been impacted by agriculture projects:

"As of 2018 the land surrounding me and throughout the community was pursued as avocado orchards, destroying and reshaping the environment to make it more suitable for monocrops to be planted for profit. This deeply affected the community. With small water tests to our local rivers, we learned that our environment was becoming polluted due to the agricultural practices, and it's all spilling right out into our harbor." [4]

Stah offers a unique perspective, as she grew up on a regenerative food farm and she watched her parents give back to the natural environment around them while growing their own healthy food for their family.

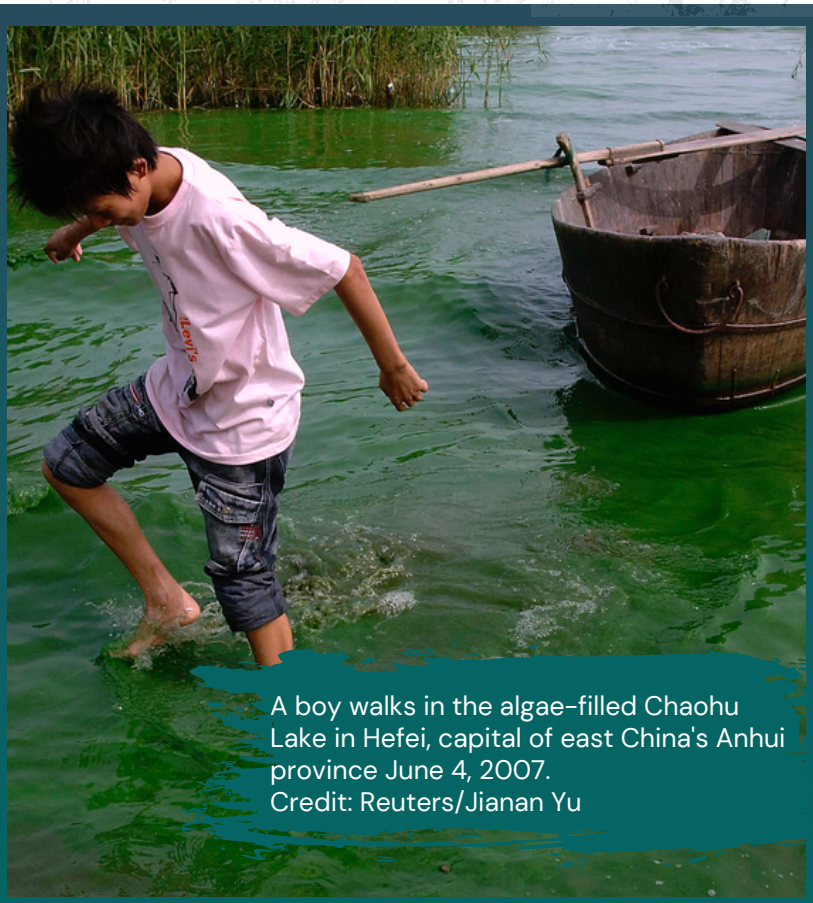
Dakota Peebler, a 15-year-old youth activist living on Yelamu land in the San Francisco Bay Area, California, has been educating herself and others on the harms of chemical fertilizer use and industrialized agricultural practices for the last 5 years. She shares:

"I have always had a deep connection to the world around me, especially the ocean, and with this came a wanting for knowledge. At a very young age I began to see the problems our planet is facing, especially our oceans -- toxic algae, plastic pollution, ocean acidification, warming waters, and more. These are all big problems that must be tackled now, but ***there are many issues that are not brought up in important conversations such as the overuse of chemical fertilizers.*** *No one really thinks of this cheap additive as problematic, but it is. The harms of chemical fertilizer use is overlooked and underestimated and must be brought to everyone's attention and made a priority. My concern led me to learn about the vast harmful world of degenerative agricultural practices. Who knew that how we grow the food we eat has such a large impact on the world around us." [5]*

There is a problem on every youth's radar as **the greatest problem our generation is inheriting**:

The Climate Crisis

Perhaps the solution is right under our feet...



A boy walks in the algae-filled Chaohu Lake in Hefei, capital of east China's Anhui province June 4, 2007.
Credit: Reuters/Jianan Yu

On the low-lying shores of the Marshall Islands, houses are battered by waves because of sea-level rise driven by climate change. 2008 Credit: The Marshall Island Journal

SOIL: THE SOLUTION TO CLIMATE CHANGE?

"Soil carbon stock is the balance between input and output. The input is through plant photosynthesis and subsequently root exudates and plant litter (from both roots and aboveground litter) as well as through compost and other types of amendment. Output is through crop harvest, erosion, and soil heterotrophic respiration – soil microbes, like humans, also consume organic carbon compounds and respire CO2. Degenerative conventional agriculture turned soil from a [carbon] sink to a sourc by promoting the output and reducing the input. ***Regenerative agriculture can mitigate climate change by turning soil back into a [carbon] sink****." [6]*

-Dr. Yichao Rui, Rodale Institute

Right now, as you read these words, all living beings, including humans, are suffering environmental catastrophes that out-scale any we have seen before in human history, and we must seize the opportunity to step away from the precipice of irreversible damage. The release of tremendous quantities of greenhouse gases being released into the atmosphere along with the destruction of our carbon-sequestering natural resources is significantly disrupting the world in which we live, and our generation is well aware of what we are inheriting. Although there are multitudes of solutions that have and are being proposed, one of the most powerful and utilizable solutions, globally, is right beneath our feet.

Earth's soil stores about three times as much carbon than that which is present in our atmosphere. [6]

Almost a quarter of the greenhouse gases (GHG's) released into the atmosphere come from the destruction of our soil, and what is worse -- these emissions are continuing to rise. [7]

Around the world, agriculture is responsible for more human GHG emissions than transportation. Why? Between 2000-2010 annual GHG emissions from agricultural production were estimated at 5.0–5.8 billion tons of CO2 equivalent emissions per year. [8] At the high end, this is roughly equal to all of the fossil fuel-derived CO2 emissions coming from China and Japan combined in 2018, and it is equivalent to all of the world's advanced economies energy-related CO2 emissions in 2019. [9] The hazardous farming techniques of modern-day agricultural practices disrupt biogeochemical cycles and are harming the planet for our and future generations.

AMENDMENTS

A soil amendment is anything added to soil to improve its abilities.
The goal of soil amendments is to provide a healthier environment for roots to grow.

Let's pull our soil situation apart to better understand it --

One could refer to “dirt” as soil that has undergone the transformation from a carbon sink to a carbon source due to the destruction of the underlying microbiology. As humans continue industrialized agriculture practices (discussed later in this paper), an increasing amount of the world's arable land is turning into non-arable dirt and releasing GHGs, especially in the U.S. and China. **Improving soil health will stop the transition from soil to dirt and prevent release of GHGs resulting in a carbon-negative solution.**

SOIL **DIRT**

There are other major negative side-effects of having poor soil including food insecurity, such as an increase in food costs and reliance on food imports. **Soil microbiome health has a unique role to play in society because soil is the foundation of human civilization.** Without the ability to grow crops plentifully and sustainably, society quickly breaks down. Improving soil health provides benefits such as ample food supply, climate stabilization, flood mitigation, and healthier people! Indigenous communities always knew this, as for millennia they have been practicing what we today refer to as “regenerative agriculture”.

THE COLONIZATION OF AGRICULTURE

INDIGENOUS AGRICULTURE PRE-COLONIZATION

Before the American Colonial Period of the Modern Age of Discovery and the move towards global colonization, Indigenous Peoples around the world stewarded and maintained the land in a mutually beneficial and reciprocal manner. Indigenous agriculture and ecological management surrounded four main concepts: intercropping, water management, agroforestry, and permaculture. [10] It centered around a core value: building, maintaining, and being accountable to place-based knowledge and the relationship with the land.

Vena A-dae Romero, a Cochiti Puebloan and Kiowa Indian farmer, shares:

"Indigenous People are as much part of the land as the land is part of us. We cultivate the land while the land cultivates us. This relationship that has supported my people since time immemorial is remembered daily when we place our fingers in the dirt, pull the weeds from our fields, or plant our seeds with water, prayer, and hope, cook the food which we grow and ingest the world with each bite of food we eat." [11]

VENA A-DAE ROMERO

Indigenous practices emphasize connection, responsibility, and accountability to all of our living relatives, including plants and animals, with the land that they are adapted to or the region where they are practiced. Indigenous food planting reflects this way of being, including intercropping.

A prime example of intercropping in indigenous agriculture is the **Three Sisters.** The Three Sisters is a 3,000-year-old practice of intercropping corn, beans, and squash. The corn is planted first to provide a structure for the beans to climb, then the beans are planted at the bottom of each stalk which add nitrogen to the soil for the corn and squash, and finally the squash are planted nearby to add shade to the soil. Some Indigenous Nations added a “fourth sister,” the “rocky mountain bee plant” which attracted bees to the plants to pollinate the squash and beans. The Three Sisters intercropping practice was adapted by Peoples of the First Nations of "The Americas" based on the climate and soil of the area. [12]

With the Three Sister planting method, each plant benefits the growth and health of the others, harmoniously.

Indigenous, traditional food growing includes a combination of intercropping and agroforestry to produce high crop yields on small plots of land, as well as water management, to designate where to plant crops.

Agroforestry is the management of crops, trees, and animals together in a way that benefits all three. It has been widely implemented by Indigenous Peoples for generations. An example of this is cafetales, a farming technique that creates a shaded system where tall fruit trees form the upper layer of the field, coffee trees are at the middle layer, and smaller food plants, like chiles, chives, and chayotes are close to the ground. The trees protect the food plants from high winds and cold temperatures, and their fallen leaves provide a natural mulch that prevents weeds, strengthens soil fertility, and retains soil humidity. [11]

Indigenous Peoples created a sustainable and beneficial system of agriculture that went on uninterrupted for thousands of years, before colonial conquests and settlement.

COLONIZATION OF AGRICULTURE

Colonizers of "The Americas" established a colonial narrative labeling Indigenous cultures and practices as “primitive”, and the healthy food growing practices were shunned. Colonial western societies put into practice rudimentary monolithic agriculture dismissing the knowledge of Indigenous People including their healthy, regenerative and sustainable agricultural methods. Industrial, monoculture farming proved to be both harmful to land and people, as it worked against the land rather than with it.

The erasure of Native Peoples' farming practices and culture, overhunting of their food sources, introducing invasive crops and animals, and forcing Indigenous Peoples onto "reservations" resulted in food insecurity and a plethora of health problems.

FOOD INSECURITY

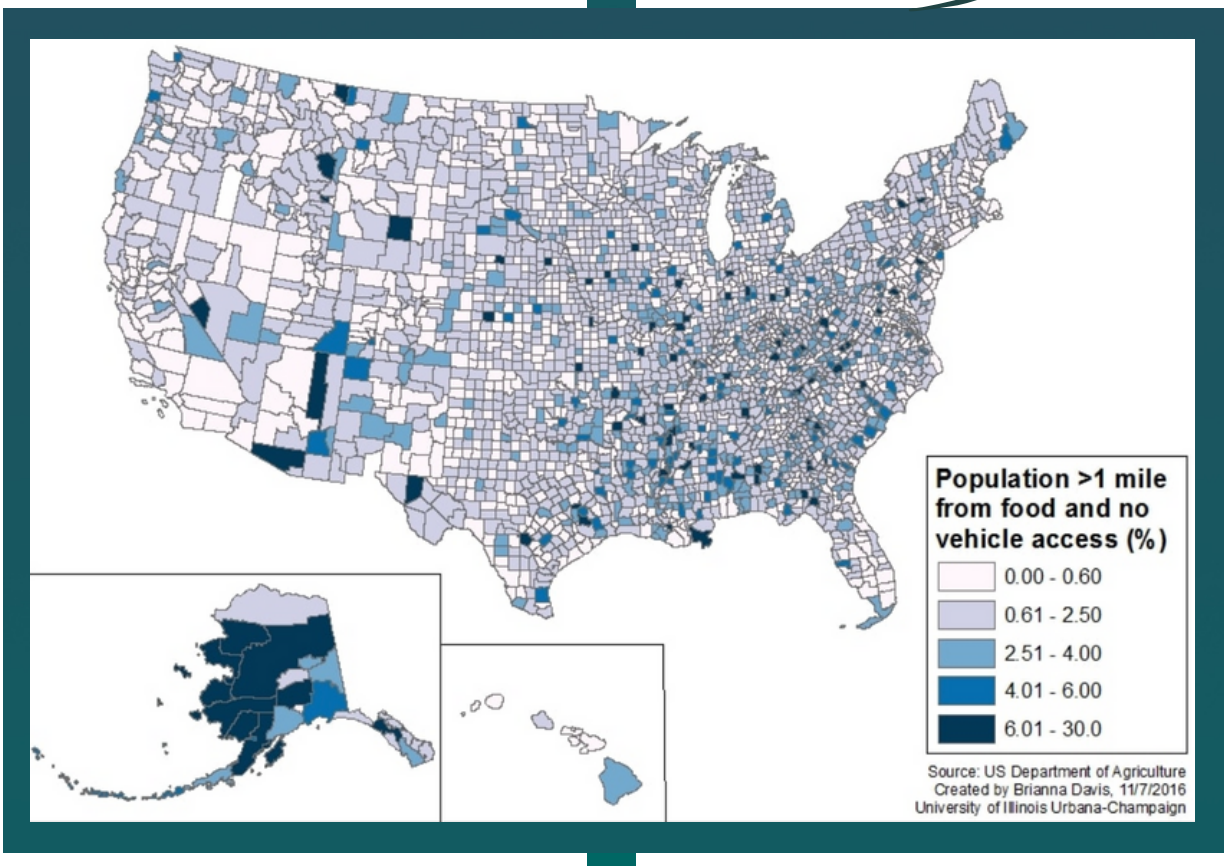
The USDA’s Economic Research Service defines food insecurity as “the limited or uncertain availability of healthy foods.” This in turn “increases the risk for obesity, diabetes, hypertension, and cancer—conditions highly prevalent among American Indians and Alaska Natives.” Reservations that Indigenous Peoples were forced to live upon are often “food deserts” as they lack affordable healthy food options including even grocery stores with fresh fruit and vegetables. This has resulted in present-day Indigenous Peoples being the most food-insecure group in the United States. [13]

A study conducted by UC Berkeley and four Native American tribes in 2019 found that "92% of Native American households in the study region suffer from food insecurity." [14] Native American family households are "400 percent more likely than other U.S. households to report not having enough to eat, largely as a result of living in remote, isolated locations where food supplies and jobs are scarce." Resources and opportunities to realign place-based knowledge and food sourcing essential to establishing sustainable health are systemically unavailable to Indigenous Peoples. [15]

While urban areas are typically thought of as having less food insecurity than rural areas, the opposite is true. Urban areas "are most afflicted by profound inequalities stemming from differences between socioeconomic groups, ethnicity, migratory status, location of residence (slums or formal settlements), city size, and a host of other factors."

There is generally an abundance of food in urban areas, but the large population of those living in poverty in urban areas have the hardest time accessing healthy, nutritious food. [16] This is due to systemic redlining and segregation of resources.

A driving factor behind food insecurity worldwide is harmful agricultural practices.



INDUSTRIALIZED AGRICULTURE PRACTICES

Industrial agriculture is a farming system that prioritizes maximizing crop yield utilizing industrial practices. Often a single species of crop or livestock is managed in a high-density environment using intensive farming practices such as use of harmful chemicals and heavy machinery. Industrial agriculture rose in tandem with the Industrial Revolution, as the development of new technologies and synthetic treatments made increased food production possible. At the same time global population boomed and the demand for food increased. Currently, the majority of the food available in supermarkets worldwide is industrially produced.

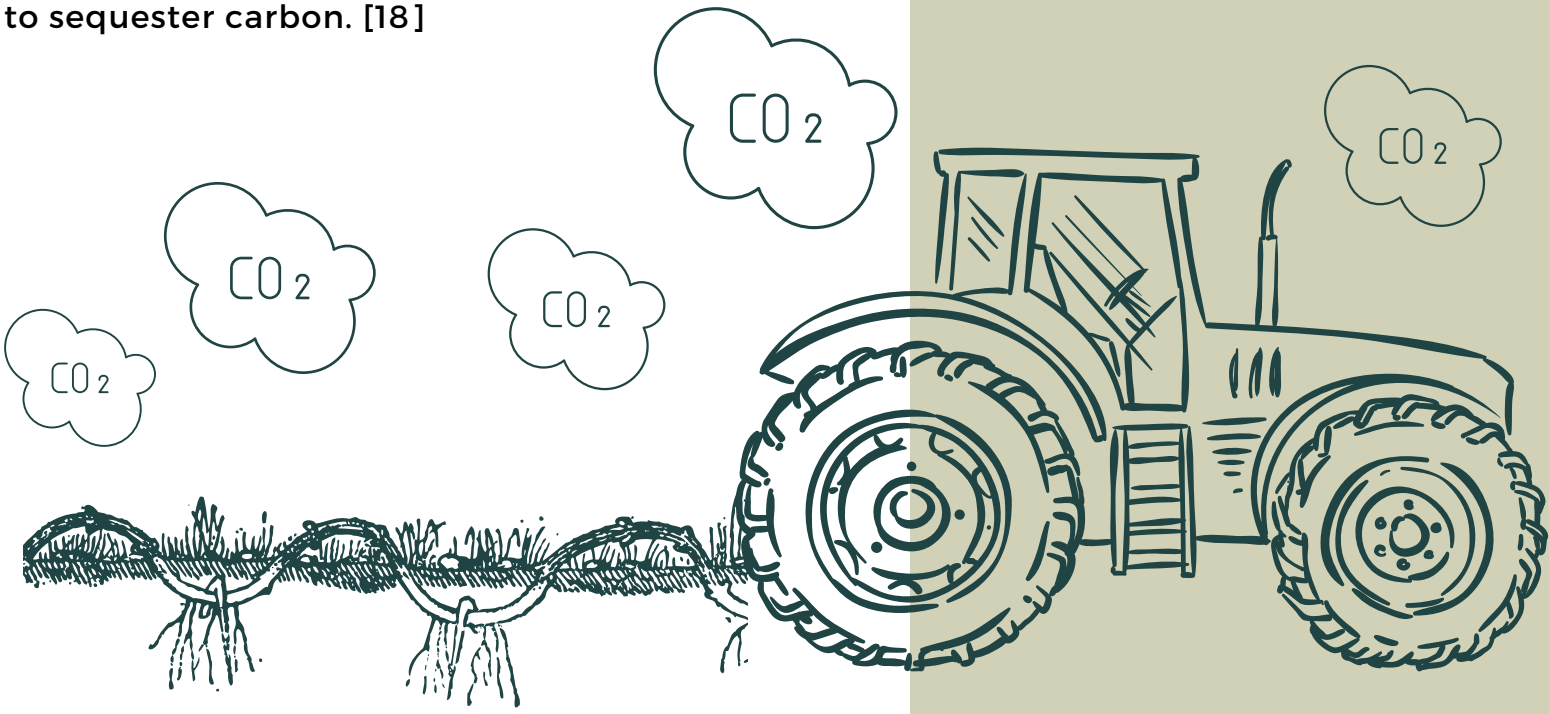
Industrial agriculture, in prioritizing yield, tends to disregard human health and the preservation of natural resources that make long-term food production feasible, such as healthy soil and clean water.

"Degenerative agriculture", a term also used frequently in this paper, refers specifically to unsustainable agricultural practices that actively pollute or degrade ecosystems that all life, including the farms themselves, depend upon.

TILLING

A widespread industrial agricultural practice ingrained into modern agriculture is tilling. According to Top Tilling, **tilling is defined as "the preparation of soil via mechanical agitation," which includes stirring, digging, and overturning.** Tilling can also be done manually through picking, shoveling, hoeing, and raking. The primary reasons for farmers to use any tilling method are to mix amendments into the soil, break up compacted soil, and/or to remove unwanted weeds and roots from the soil.

However, repeated tilling causes more harm to the land than benefit. Mechanical tillers kill earthworms and other insects living in the soil which naturally fertilize the soil. Tilling fractures the soil disrupting its structure and "accelerating surface runoff and soil erosion." [17] Another negative impact of tilling is the reduction of crop residue that allows soil particles to become more easily dislodged, hindering soils ability to sequester carbon. [18]



MONOCULTURE

Monoculture and mono-cropping are harmful, and they have unfortunately become normalized and mainstream. Monoculture is a familiar planting technique and a well-known industry for a lot of farmers. A crop has only one species planted to grow at a time, and each crop receives the same number of chemical additives and goes through the same standardized planting, maintenance, and harvesting process. This has been believed to result in high yields of one specific crop at a low cost. [19]

However, many people are unaware of the importance of plant diversity in growing food and the dangers monoculture poses. **In nature, one crop alone doesn't grow in abundance on acres and acres of land**. There are so many different plant species, animals and insects that grow and thrive together. and healthy soil naturally contains many diverse microorganisms providing the plants with nutrients. Monoculture eliminates essential microbial diversity.

MONOCROPPING

The same species of plants or crops being planted year after year.

MONOCULTURE

Growing only one type of crop, plant, or livestock on a field.

CREDIT SARA POPESCU SLAVIKOVA

"Biodiversity is critical to a high-functioning soil food web in which healthy competition keeps disease and pest pressures at bay.

Microorganisms that benefit plants and farmers decrease in soils with monoculture because there is not as much biodiversity." [20]

Cory Owens
Soil State Scientist
USDA-NRCS

Soil scientists have recently discovered that the practice of monocropping changes the landscape of soil microbes and decreases the amount of important microorganisms resulting in deficient plant growth. When the same crop is repeatedly grown on the same land, certain soil nutrients become depleted from the soil because of that specific crop's nutrient demand.

In a study conducted in Hainan, China, scientists investigated how continuous monoculture affects soil chemical properties and microbial communities in coffee plants. Researchers selected four replanted coffee fields with 4, 18, 26, and 57 years of monoculture history comparing different soil chemistry properties year after year. Their results concluded that long-term monoculture decreased soil pH and organic matter content, decreased soil bacterial and fungal richness, and decreased beneficial microbes. [21]

Youth engage in hands-on learning at Pie Ranch

When the soil's natural nutrients are eliminated, microorganisms decrease and pests increase resulting in farmers introducing artificial products like chemical fertilizers, herbicides, and insecticides. This causes a plethora of issues and worsens the cycle of degenerative agriculture.

In an interview about the documentary Vanishing of the Bees, best-selling author and environmental journalist Michael Pollan explains that

"Monoculture exhausts the soil, every plant is taking the same things from the soil and not putting things back." [22]

With monoculture the soil becomes infertile, bare and prone to erosion. According to the Food and Agriculture Organization, 33% of the Earth's soils are already degraded and over 90% could become degraded by 2050. [23] Soil erosion can cause up to 50% loss in crop yields. We must stop relying upon monoculture as a method of food growing.

Pests can pose a danger to crops and farmers on a monoculture farm, and all it takes is one major event to wipe out an entire field.

"The big issue with monoculture is having a continuous host for pests; monoculture lets the pest and disease populations build up," explained Cory Owens, a soil scientist of the Oregon Natural Resources Conservation Service. [20]

An example from history is the Irish Potato Famine, where genetically identical potatoes were susceptible to rot because of a disease Phytophthora infestans, a species of soil-inhabiting pathogens. [24]

In a 2016 study conducted at UC Davis, researchers examined how plant diversity influences plant-eating insects. The study concluded that a farm growing a variety of plants attracts fewer insect pests than a field growing one type of crop due to the nutritional needs for pests. [25] If an insect likes the taste of a particular crop, that insect has a plethora of food to devour in one convenient space.

The 2016 US Davis study determined that **if there is a field containing a variety of crops, this does not offer a surplus of food for the insect and the pest will not receive the nutrients it needs to survive.** [25]

"Monoculture is like a buffet for plant-eating insects where every dish is delicious; a variable crop is like a buffet where every other dish is nasty." [25]

William Wetzel
Assistant Professor
Michigan State University
UC Davis 2016 study participant

Crop rotation and cover crops help to break pest and disease cycles by adding biodiversity that counteracts potential crop danger.

PESTICIDES

One of the primary ways that monoculture ecosystems in industrialized agriculture are maintained is through the use of pesticides. The word pesticide consists of two parts, “pest” and “icide.” Pests are anything living that disturbs, and therefore is unwanted by, humans. The suffix “icide” adds the meaning “to kill a particular person or thing.” While the intention behind all kinds of "icides" for use in agriculture is to help humans by giving us more food and benefiting our health, they commonly lead to substantial unintended side-effects. The hazards vary widely depending on the specific chemical, but impacts range from minor inconveniences such as skin irritation to major health risks including damage to the nervous system and cancer. [26]

There are many different types of pesticides, ranging from those that target disease-carrying animals to those that aim to mitigate weeds or harmful bacteria in agriculture. All types of pesticides aim to control or destroy pests. [27] It is also important to realize that **the living beings we deem “pests” play a valuable role in the ecosystem that they, and we, live in. Humans often use pesticides with a blatant disregard and lack of respect for these creatures and their role in their respective ecosystem, doing a lot of harm to the world we live in along with them.**

Pesticides are composed of two types of ingredients: inert ingredients and active ingredients. Active ingredients are those that directly destroy, mitigate, or repel a target pest. Most commonly, these include chemicals like glyphosate, 2,4-D, atrazine, dicamba and malathion. [28] Inert ingredients are combined with active ingredients to enhance a product’s usability or performance. These can be chemical or natural, but importantly, inert ingredients can be toxic. [29]

Youth assists in putting in irrigation drip lines as a water saving strategy at Pie Ranch

PESTS

Any animal, plant, fungi, or bacteria that poses a threat to, or is unwanted by, humans.

INERT INGREDIENTS

Added to active ingredients to enhance a product's usability or performance.

ACTIVE INGREDIENTS

Directly destroys, mitigates, or repels a target pest.

INSECTICIDES

Insecticides are pesticides intended to eliminate insects that threaten crops. Unfortunately, insecticides can harm species other than the target species.

Some insecticides are repellent, meaning insects detect the danger and steer clear of the chemicals. Non-repellent insecticides not only affect the insect exposed, but entire colonies of social insects such as ants and honeybees, as they return to their colonies carrying poison that can result in colony collapse.

Bees, crucial pollinators in the U.S, are especially vulnerable to insecticides. Cocktails of agrochemicals act as stressors that harm bees, increasing bee mortality. [30] At present, both wild bees and kept honey bees are threatened. Declining pollinator populations in recent years are a concern to natural ecosystems and cultivated farmland alike. [31]

Additionally, a decrease of bird populations has been linked to Neonicotinoids, a widely-used family of insecticides. [32]

FUNGICIDES

Fungicides are a type of pesticide that is largely based on sulfur and metal ions such as copper, tin, and mercury, components all toxic to fungi. [33] Fungicides are considered by some to be the most important addition in horticultural disease management because of the impact fungal disease has on crops. However, most fungal diseases are incredibly hard to eradicate as disease outbreaks can often continue over several growing seasons, even with the application of fungicides.

Heavy use of copper-based fungicides has been known to result in copper accumulations in the soil which kill off the soil's organisms, including essential earthworms and microorganisms, posing a major threat to the long-term fertility of the soil. The impacts fungicides have on the environment has been considerably overlooked compared to emerging studies on the impact of insecticides and herbicides. Only 13% of studies on pesticide effects between 1991 and 2013 focused on fungicides compared to 62% and 24% for insecticides and herbicides, respectively. [34] Following their use, fungicides can enter aquatic ecosystems via point-sources -- any single identifiable source of pollution from which pollutants are discharged -- and nonpoint-sources -- pollution coming from many sources. **In aquatic systems, fungicides can be toxic to a wide range of organisms as their components are toxic to organisms, not just fungi.** [35]

HERBICIDES

A second widely used agrochemical is herbicide designed to kill unwanted plants or "weeds". Herbicides are very common in agriculture, representing about 60% of the pesticides used worldwide. [36] Although the world has been using herbicides for over 50 years, there remains a "weed problem". According to Andrew Cobb and John Reade in Herbicides and Plant Physiology, "the 'weed problem' will never go away as long as crops are grown and harvested." Plants grow on the natural ground of planet Earth, and weeds are plants. [37]

HORTICULTURE

Relating to the art or practice of garden cultivation and management

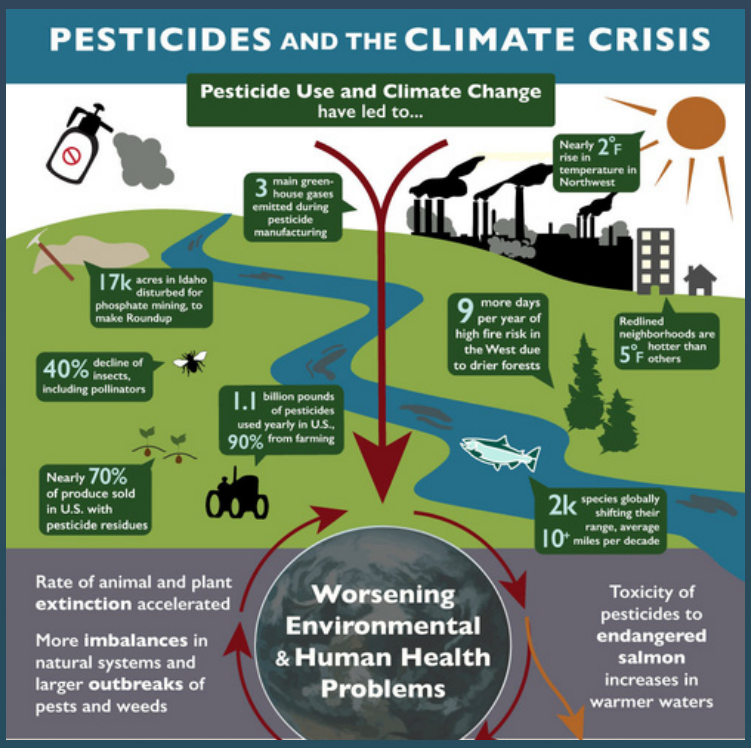
NITROGEN CYCLE

Process where nitrogen and its compounds interchange in the environment and living organisms

When herbicides are applied to crops, they contaminate the soil and the plant (1) disrupting earthworms which play the critical role of decomposing biowaste and mixing the soil, (2) inhibiting the soil's ability to partake in the nitrogen cycle, and (3) increasing disease in crops. [38] Soils that are high in organic matter or clay, or that have a medium to fine texture, are also especially susceptible to retaining herbicides within them. This can lead to a buildup of herbicides within the soil content that can harm crops planted in the future. [39]

Additionally, herbicides have indirect impacts on soil health. Herbicides are created to directly kill off-target plants, decreasing plant biodiversity to promote a monoculture ecosystem. This can indirectly decrease the biodiversity and populations of other organisms within the soil. As herbicides kill what we refer to as "weeds," these dead plants are also absorbed by the soil changing the composition of its organic matter content and increasing chances of soil erosion. [40]

Herbicides can have long-lasting effects on all environments that they interact with since they remain persistent in soils and can run off into water bodies to cause more contamination. [39]



CREDIT: NORTHWEST CENTER FOR ALTERNATIVES TO PESTICIDES

Youth participate in hands-on learning at Pie Ranch, Pescadero, California

CHEMICAL FERTILIZER

Crops need nutrients such as nitrogen, phosphorus, and potassium to grow. Soil organic matter contains all of those nutrients, but it is stored in less available organic forms. When crops need nutrients, they release signals through plant-microbe interactions, so microbes mineralize those nutrients to feed the crops. In return, plants provide root exudates carbon to feed the microbes. [41]

Inorganic chemical fertilizers are salt-based compounds that crops directly take up bypassing biological processes allowing for quicker growth. While the use of chemical fertilizers was seen as revolutionary in the post-WWII era, and seen as a great step toward feeding the world, this inexpensive chemical substance is over-used resulting in catastrophic impacts to the world we live in. [42] **Using chemical fertilizers to grow food results in (1) a decline in microbial abundance and diversity affecting the ecosystem's biodiversity, (2) unbalanced soil chemistry (e.g., a decline in soil pH), and (3) a decline in soil organic carbon and causing soil compaction.** [41]

Although it may seem that applying synthetic fertilizers to crops would aid in plant growth, the truth is that these inorganic substances have damaged soil health resulting in unstable productivity and weak, microbe-depleted soil. This results in a harmful cycle where even more synthetic fertilizer is added making the soil even weaker. More so, over half of the fertilizer applied to food crops is lost into the environment resulting in a multitude of other issues that will be discussed later. [41]

Due to the impacts chemical fertilizer has on soil health, farms and ranches have begun to move away from them. **Gabe Brown is a rancher in North Dakota who moved from degenerative practices to practicing what his ranch calls Holistic Management, farming and ranching in nature's image**. Brown's Ranch uses diverse cropping strategies, practices no-till, and has eliminated all pesticides and chemical fertilizers. According to Brown, **both profitability and regeneration have increased significantly on the ranch as a result of eliminating synthetic fertilizers**. Without the addition of synthetic fertilizers, his soil is full of microbes providing crops with the nutrients they need without having to pay extra for a chemical product that will do vastly more harm than good. [43]

SOIL ORGANIC MATTER
Components of soil that consist of plant and animal waste at various stages of decomposition

ROOT EXUDATES
Substances released by roots of living plants consisting of low-molecular-weight organic compound.

SOIL ORGANIC CARBON
Solid carbon stored in global soils consisting of soil organic matter.

Without the use of chemical fertilizers, farms and ranches can be even more productive once regenerative practices are put into place to rebuild soil health and revitalize the carbon and nutrient cycles.

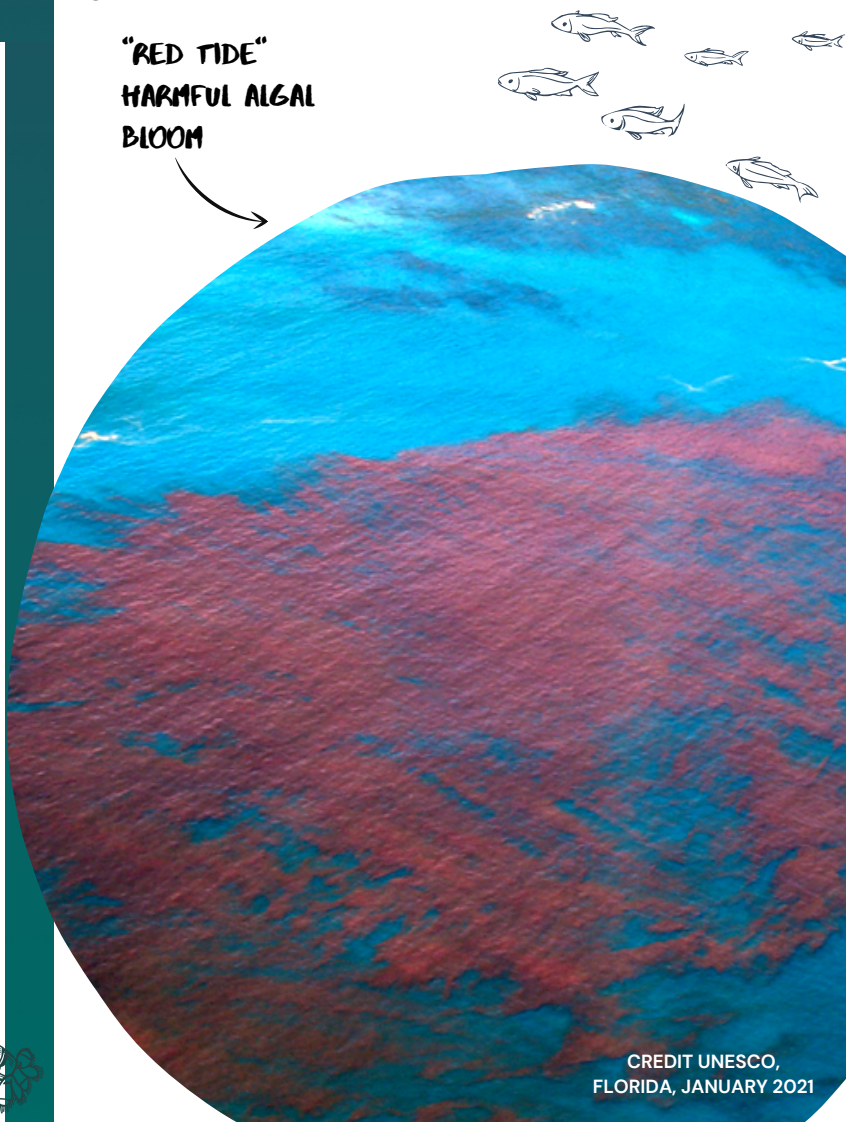
This re-balancing results in long-term productivity as well as stability and resilience in managing climate extremes.

The Farming Systems Trial is the longest-running side-by-side comparison of organic and conventional agricultural systems in North America. Research Director Dr. Yichao Rui recommends that farmers find access to a **high-quality** organic amendment to build healthy soil and design **crop rotation** with efficient carbon and nutrient cycling. This will maintain soil fertility and productivity while also significantly **reducing expenses**. [41]

According to Kainoa Azama, in Hawaiian culture they utilize green waste, including leaves and feces, to compost and provide organic nutrients to their crops and feed their communities without harming the land or waters. Fire was also used in dry areas to prevent wildfires and provide much-needed ash fertilization into the ground. [3]

HARMFUL ALGAL BLOOMS

The impact that synthetic fertilizer has on soil is not the only problem it creates. As mentioned earlier, synthetic fertilizers often are not fully absorbed by plants, leaving much lost in our environment. Where does it go? **The waters of our Blue Planet receive significant nutrient runoff from those lands increasing the chances that harmful algal blooms will occur,** either directly through surface runoff or indirectly through groundwater inputs. [44] Chemical fertilizers carry these nutrients and are large contributors to the runoff problems. Chemical fertilizers work as a growth stimulator in plants not only on land but also in the water stimulating algae growth. [45]



CREDIT UNESCO, FLORIDA, JANUARY 2021

Algae is a very important marine botanical that produces much of the oxygen we breathe and plays a critical role in the marine food chain. [46] When certain types of algae are stimulated, there is a high chance that neurotoxins, hepatotoxins, and dermatoxins will be released into the water. [47] These are the start of Harmful Algal Blooms (HABs).

HABs are colonies of algae that grow out of control and produce toxins that harm people, fish, shellfish, marine mammals, and birds.[48]

HABs have occurred in all types of aquatic ecosystems ranging from headwater streams to coastal waterways. Blooms have also occurred across systems with a range of nutrient status, and there is evidence that the occurrence is greater in areas with **higher nutrient concentrations**. One example of an algae that produces a **harmful toxin** when stimulated is pseudo-nitzschia, a diatom that is known to produce domoic acid.

Domoic acid is a neurotoxin that accumulates in shellfish, finfish and in humans. [44]

Minimal oral exposure to this toxin results in **gastrointestinal effects**, and slightly higher doses elicit **neurological symptoms, seizures, memory impairment, and limbic system degeneration**. In marine mammals, such as sea otters and sea lions, oral doses cause behavioral abnormalities followed by seizures and hippocampal degeneration. [44] Domoic acid first became known in 1987 when the toxins were found in shellfish from Prince Edward Island, Canada, which had been consumed by humans. Three people died, and 100 people developed **toxic symptoms.**

"In 2001, along the beaches of Monterey Bay, California, dead and dying seabirds were observed —many of the sick birds displayed unusual symptoms suggesting a neurological toxin. Examination of the contents of the dead birds' stomachs revealed high levels of domoic acid. Furthermore, the birds had been eating anchovies from the bay. In turn, examination of the anchovy gut contents showed that these fish had been consuming the diatom called Pseudo-nitzschia. Quick action by state health departments along the West Coast of the United States prevented human illnesses by closures of both recreational and commercial shellfisheries." [49]

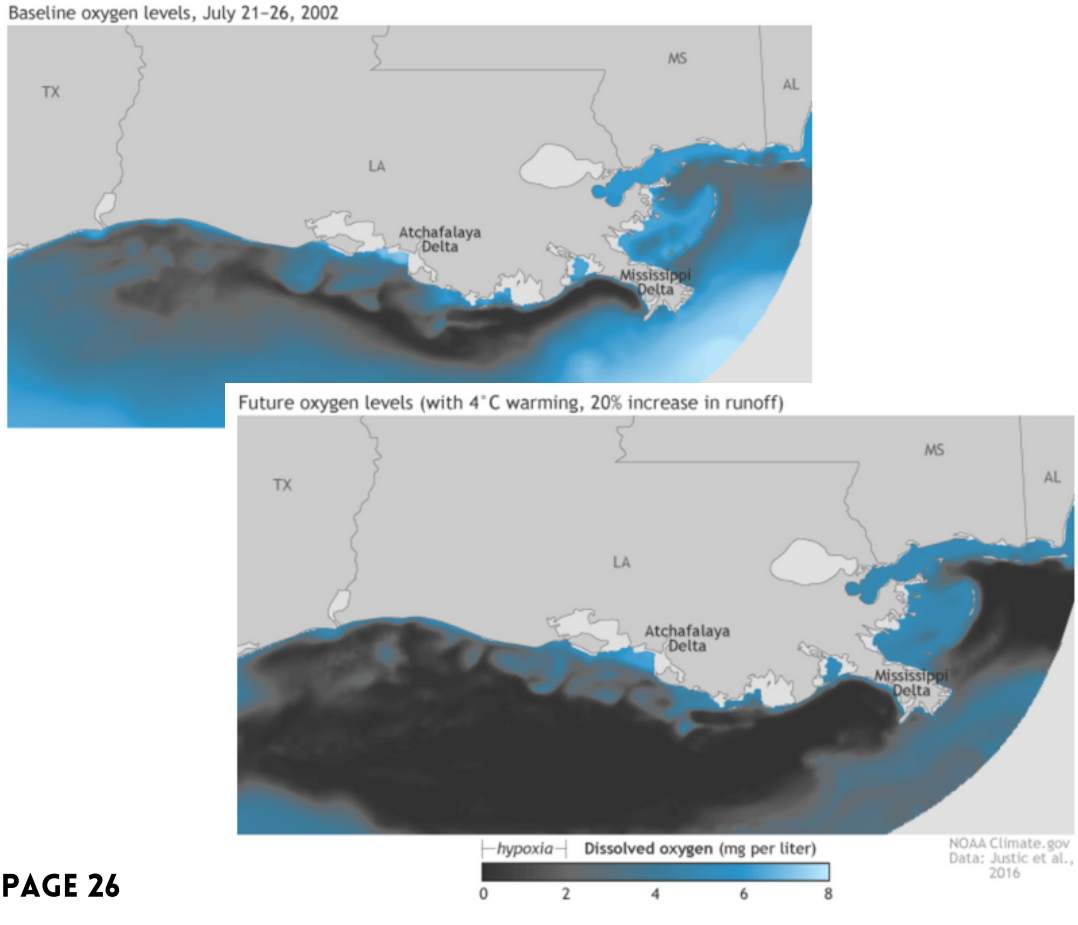
National Oceanic and Atmospheric Administration

DEAD ZONES

After a large algae bloom occurs like the one in 1991 in Monterey Bay, the algae decompose but the bacteria that assists in this process sucks the oxygen up from that water in that area resulting in what are called **“dead zones”** or **hypoxic zones.**

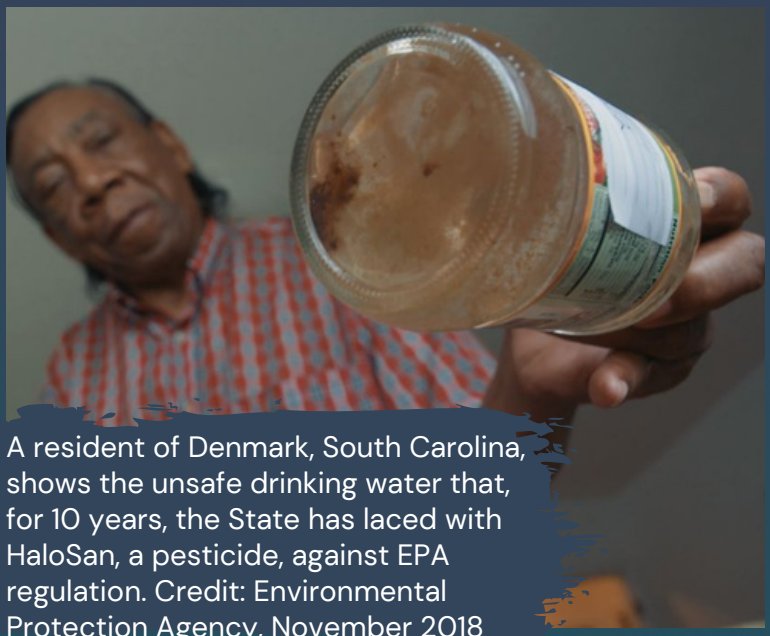
These zones are places that no longer have enough oxygen for marine life to survive, turning them into parts of water that are void of life.

In 2017 the Gulf of Mexico suffered from a dead zone roughly the size of New Jersey (8,776 square miles). It was the largest dead zone ever recorded. **This dead zone has occurred almost every summer,** decreasing biodiversity and productivity and leaving behind a trail of devastating impacts. [50] In 2012, there were around 400 dead zones globally, and with the current trajectory of nutrient pollution and warming waters, this number will only go up over time if humans continue to overuse fertilizers. [51]



GROUNDWATER CONTAMINATION

Nutrients of overused commercial fertilizers, including Nitrogen, making their way into watersheds are also leaching into sources of drinking water. According to the Groundwater Foundation, "groundwater supplies drinking water for 51% of the total U.S. population and 99% of the rural population." [52] Groundwater is an important source of drinking water for many U.S. citizens and yet many groundwater sources are contaminated by pollutants including nitrates (a form of Nitrogen) that commonly leach through the soil. According to UC Davis' 2016 California Nitrogen Assessment, which looked at a 7-year period, each year 419,000 tons of nitrogen leach into groundwater with nitrate, making it California's most widespread groundwater contaminant. And California is a Big Agriculture State. [53]

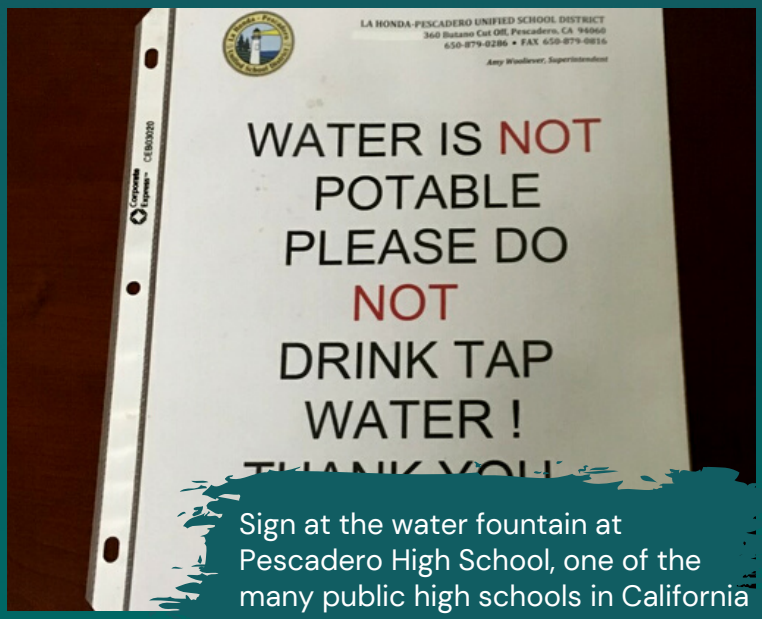


A resident of Denmark, South Carolina, shows the unsafe drinking water that, for 10 years, the State has laced with HaloSan, a pesticide, against EPA regulation. Credit: Environmental Protection Agency, November 2018

One of the most disturbing problems of nitrate contamination is that many schools do not have access to safe drinking water. According to a Community Water Center report, between 500,000 to over a million California students attend schools whose water systems don't meet primary safe drinking water standards. [54]

Farmworkers and agricultural communities often struggle with drinking water contamination due to agricultural runoff. These impacts tend to affect people of color and socio-economically disadvantaged groups the most. [55]

Chemical fertilizers are overused all over the world and are directly affecting human and marine health and our soil which is the provider of life.



Sign at the water fountain at Pescadero High School, one of the many public high schools in California that lacks safe drinking water.

FACTORY ANIMAL FARMING

Factory animal farming has been the recipient of attacks on multiple fronts in recent years, especially in developed countries where it is so widely practiced. In fact, it is estimated that **99% of US farmed animals are living in factory farms** according to census reports by the US Department of Agriculture. [56] Leaving aside the questionable ethical practices involved with factory farming, there are serious reasons to focus on this issue from ecological and humanist reasonings.

Factory farming harms our planet and therefore us. According to Pace University, factory farming animals produce more than 1 million tons of manure every day. This animal waste often contains **antibiotics, pathogens, hormones, chemicals, and heavy metals** which had been given to the livestock to prevent the spread of disease in their confined living conditions. The contaminated animal waste is typically stored in lagoon areas near open bodies of water, and when flooding occurs this storage **spills everywhere** into the bodies of water and contaminates it, killing fish populations and other marine life in the process. [57] A 2005 study found that animal waste pollution has a significant effect on the bacterial and nutrient levels in runoff water, which threatens other water resources downstream. [58] Contaminated water and water degradation from animal waste as a result of factory farming is a **human health issue**.

Additionally, livestock accounts for about 5.8% of all anthropogenic (human-caused) greenhouse gas emissions (GHG). [59] A substantial amount of this is attributable to just one animal — cattle. Cows and other ruminants create large amounts of the powerful GHG methane when they digest food.

CREDIT METT GARLING / MISSION BLUE

RUMINANTS

A sub-group of mammals that also includes deer, sheep, giraffes and others

"An accountable societal governing structure allows us to recognize the life that's lived and the gift that's given. **INDIGENOUS TRADITIONAL WAYS** include engaging in ethical and sustainable harvesting methods and using responsible and considerate behaviors in navigating how and when to take an animal's life. That is integral to maintaining our relationship to living beings as well as the bio region they live in." [17]

KANYON COYOTEWOMAN SAYERS-ROODS

DECOLONIZING AGRICULTURE

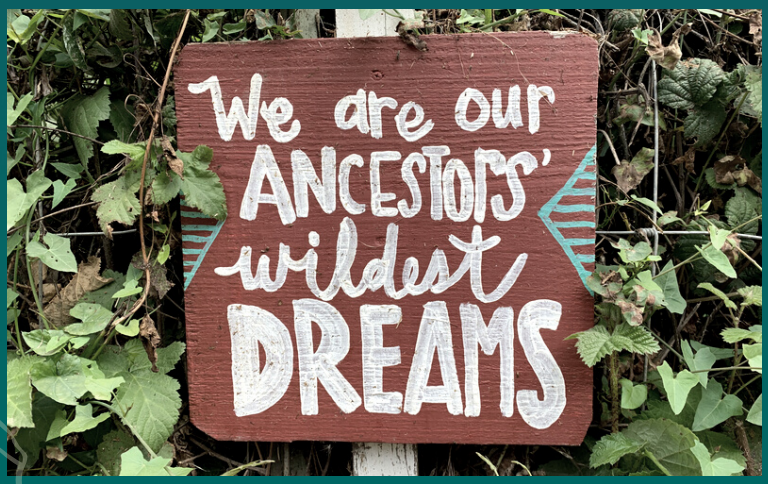
Even though the majority of the U.S. is rooted in industrialized, degenerative agriculture stemming from colonization, we can turn the destruction around through decolonizing agriculture and return to using regenerative agricultural practices that have their roots in indigenous systems. As shown in the previous section, after indigenous systems and agriculture are wiped out and industrial food growing methods are practiced, the health of our communities and planet plummet.

In Arty Mangan's interview of **A-dae Romero-Briones**, Director of Programs at First Nations Development Institute, Ms. Romero-Briones reminds us that "food is an indicator of the health of a society." [60] The food systems in place today are all too often unhealthy, unsustainable, and unjust. According to a USDA Economic Research Service report from 2009, approximately **23.5 million people** in the United States live in food deserts.[61] This number is just one of the many ways our planet and communities reflect the **injustice** inherent in the current industrialized food system. But there are ways we can turn these crises around!

In her book **Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants,**
Robin Wall Kimmerer offers her thoughts on easy ways we can all create a better world.

"Know the ways of the ones who take care of you, so that you may take care of them.
Introduce yourself.
Be accountable as the one who comes asking for life.
Ask permission before taking.
Abide by the answer.
Never take the first. Never take the last.
Take only what you need. Take only that which is given.
Never take more than half. Leave some for others.
Harvest in a way that minimizes harm.
Use it respectfully.
Never waste what you have taken.
Share.
Give thanks for what you have been given.
Give a gift in reciprocity for what you have taken.
Sustain the ones who sustain you and the earth will last forever." [62]

Robin Wall Kimmerer



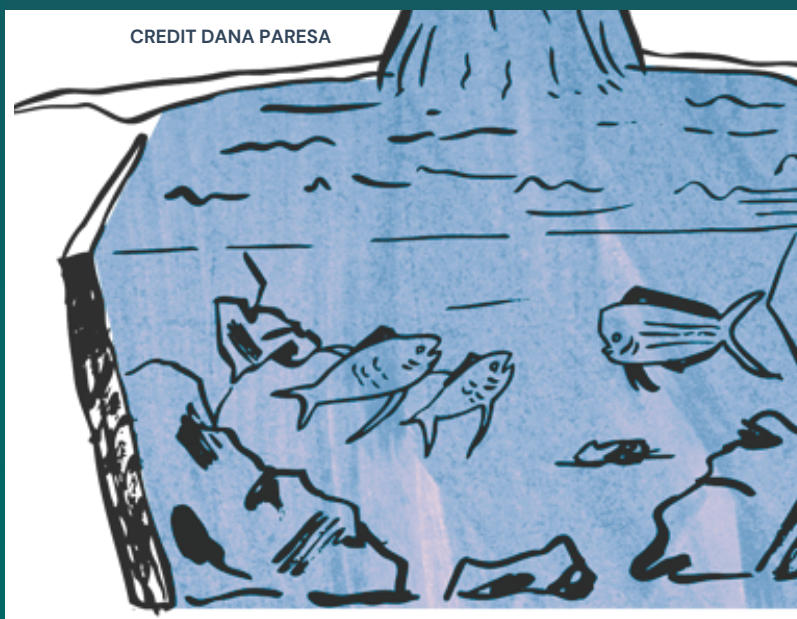
The indigenous-inspired regenerative approach is one that centers on having **respect for the life source** you are using and the needs of other living creatures around you, building a **reciprocal** relationship with all members of the food system you are a part of. This is truly the foundation of **decolonizing** our agricultural systems. Using this methodology will create a sustainable form of living that will last forever.

The process of decolonizing our agricultural system begins with changing our mindset and interactions with our food systems. We can do this by reimplementing indigenous ecological knowledge into our agricultural practices.

In the interview mentioned above, A-dae Romero-Briones points out the key distinctions between indigenous agriculture and the modern agriculture:

"There are stark differences between agricultural systems in indigenous communities and agricultural systems in contemporary communities. The first being the idea of collective resources. In an indigenous community, there are some things that just cannot be commodified: land, water, air, animals, even the health of the people, all of which are considered collective resources." [60]

A-dae Romero-Briones


CREDIT DANA PARESA

In today's society, we have commodified our life sources, turning our backs on the concept of sharing them as communal resources and losing our respect for the systems that sustain us. Kanyon Sayers-Roods, an Ohlone and Chumash native representative, shares, similarly, "When we look at the driving force between monolithic or industrialized agriculture, it's not about feeding the nation, it's about profit." [17] We have completely moved away from a mutually beneficial, holistic approach to sustaining our communities and environment. However, returning to using Indigenous practices and traditional ways of interacting with these food systems can save us.

Indigenous agricultural practices are key in preserving biodiversity, which helps to create climate resilient communities and ecosystems and food security, especially in places heavily threatened by the impacts of climate change. [63]

However, it is a big concern that this critical indigenous knowledge is threatened by globalization and a conventional mindset that values modernized commercial ways rather than traditional. A 2001 study on indigenous **agroforestry** and crop practices found that while it may be useful to try and preserve and maintain certain, specific agricultural practices, it is more important to preserve the indigenous concepts that these practices are centered around. [64] While we use science to further the decolonization of agriculture and find sustainable ways to provide for our society, it is time to bring attention to indigenous knowledge on these topics. It provides a crucial and critical balance and perspective in this field. To truly change the system of agriculture that we have created in our society, as Ms. Wall Kimmerer shared, we must return to one where reciprocity and respect for all life sources — water, soil, and air — are at the forefront of our decision making.

The **localization of food systems** is a critical step in decolonizing agriculture, as it addresses food security and provides economic and educational opportunities. We've seen in the previous section how the crisis of our current agricultural system causes food scarcity, especially in low-income and minority communities. [61 Localizing food systems, such as creating community gardens, can bring food security back into these vulnerable communities while also providing crucial education and employment opportunities for youth. [65] Growing and selling food within a community can boost the local economy and encourage healthy and environmentally conscious ways of eating within the community. [66]

The process of decolonizing agriculture also involves **understanding and teaching** about what we refer to today as "regenerative agriculture". According to Regeneration International, "Regenerative Agriculture describes farming and grazing practices that, among other benefits, reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity resulting in both carbon drawdown and improving the water cycle." [67] This term stems from the word "regenerate," or the process by which something is regrown, reformed, or reborn.

Regenerative agriculture seeks to renew ecosystems previously impacted by industrialized and colonized agricultural practices.

The term r**egenerative agriculture** may seem new and scientific, but the regenerative practices we refer to with the use of this term aren't new at all. In fact, they all stem from indigenous methods of farming that have been **used for millennia,** many of which are still being used by Indigenous Peoples today. When talking about "regenerative agriculture", we are really talking about the traditional farming processes that can be used to rejuvenate the **life sources** we have commodified and help us decolonize these agricultural systems.

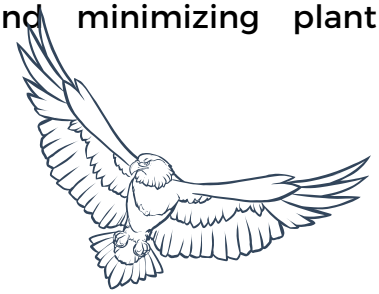
Regenerative agriculture can be broken down into five key practices: (1) **Minimizing soil disturbance or tilling**, (2) **minimizing the use of harmful additives**, (3) **implementing barrier crops**, (4) **utilizing cover crops**, and (5) **fostering plant and animal biodiversity**. The sixth key principle is using these practices in the context of available resources, climate, and geographic region. **What do the 5 practices look like more in-depth? Let's take a look...**

NO-TILL

In order to respond to the issues related to excessive tilling on agricultural land, ancestral practices such as no-till are being increasingly fostered by American farmers. No-till farming consists of growing crops or managing pastures without altering the soil. [68]

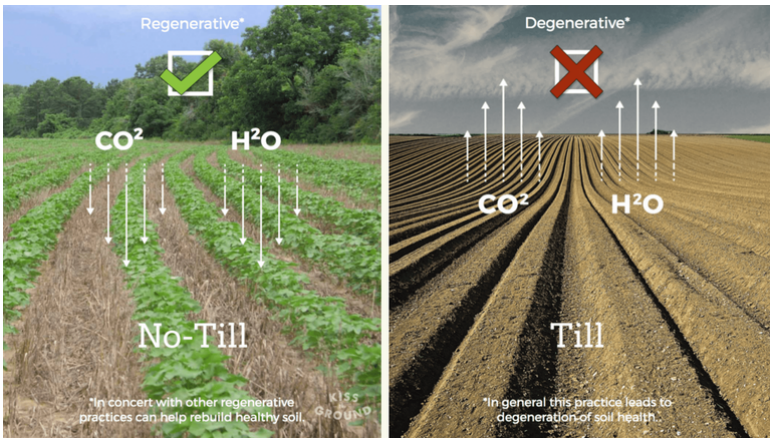
In his 2010 book Soils, Plant Growth and Crop Production, **Willy H. Veryheye** explains the basic methods used in no-till farming. Although in conventional tillage the earth is turned to a depth 8 to 12 inches with a plow "to prepare the seedbed," no-till carries out planting directly through the residues of the previous plantings and weeds without disturbing the soil. [69] The seeds are therefore directly deposited into untilled soil. Special no-till seeding equipment is supposed to open a narrow slot into the residue-covered soil, which is only wide enough to put the seeds into the ground and cover them with soil.

This method allows the soil to stay intact and protects it by leaving crop residue on its surface. No-till increases the soil's ability to absorb water by improving its structure and soil cover. It also benefits soil microorganisms like fungi and bacteria that are essential to the soil's health. When the land is left intact, those organisms can develop more efficiently and feed off of the soil's organic matter. This allows for a healthier soil microbiome, critical for nutrient cycling and minimizing plant diseases. [70]



As the soil's microbial life becomes richer, the soil's internal structure inevitably improves allowing it to grow more nutrient-dense crops. This technique has also been shown to slow evaporation, which improves irrigation efficiency and absorption of rainwater. Under those circumstances, it reduces soil erosion, keeps water from draining away, and therefore prevents chemicals from entering nearby water sources. [70]

In his 1943 book Plowman's Folly, the **agronomist Edward H. Faulkner states: "The truth is that no-one has ever advanced a scientific reason for plowing."** [71] This controversial publication challenged the necessity of the plow and tilling in general for farmers in the U.S. In 1962. Harry Young, Jr. established the first commercial no-till production plot in the country. From there, increasing research on modern methods of no-till agriculture began in earnest throughout the 1960s. This marked the beginning of rising popularity for no-till farming. Six decades later, technology and research transformed this technique into a profitable practice that now spans over 90 million acres of farmland in the United States. [72]



CREDIT KISS THE GROUND


Credit José Galindo

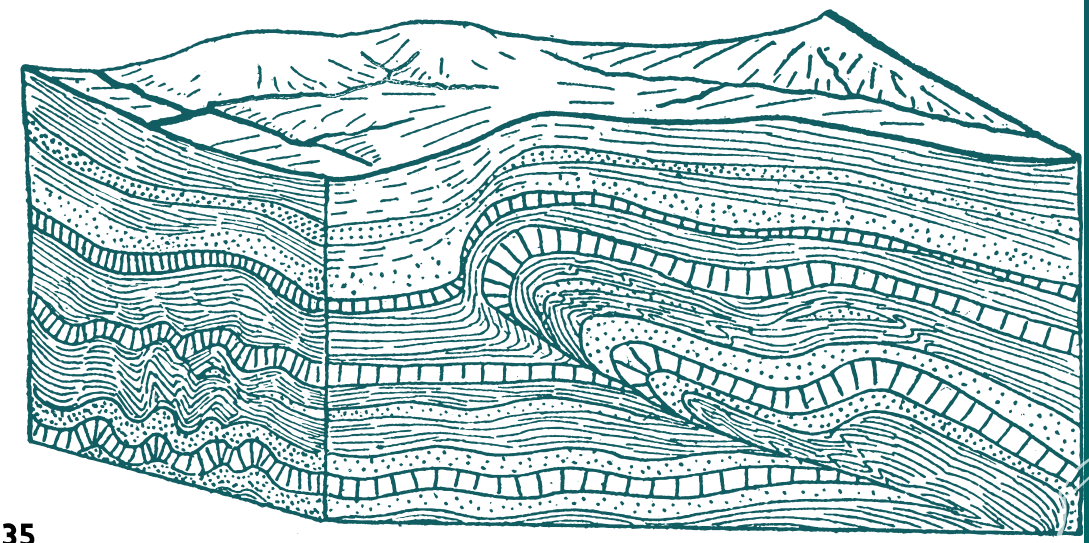
TRADITIONAL FRIJOL TAPADO FARMING

Although this method of cultivating the soil only gained popularity with American farmers after the second half of the 20th century, it stems from ancestral traditions that go as far as 10,000 years ago. [73] According to The Quiet Revolution report published by David R. Huggins and John P. Reganold:

"In the transition from hunting and gathering to raising crops, our Neolithic predecessors planted garden plots near their dwellings and foraged for other foods in the wild. Some performed the earliest version of no-till by punching holes in the land with a stick, dropping seeds in each divot, and then covering it with soil." [73]

Those techniques have been observed in various indigenous cultures around the world, in particular with the **Incas in the Andes of South America and the ancient Egyptians.** In a study reported by the University of Cambridge The Living Fields: Our Agricultural Heritage, J. R. Harlan revealed that those civilizations routinely used a stick to make a hole in the soil in order to put seeds in the ground by hand and cover them with the foot. The **"hill planting"** of placing seeds in individual holes allowed the use of mixed cultures, such as with beans, maize, and squash in the same field. [74] This system of farming is still used today by some Indigenous Peoples.

Other no-till practices were developed by pre-Columbian cultures long before the term "no-tillage" was introduced in the English vocabulary. A publication by Cornell University professor David Thurston entitled Sustainable Methods for Tropical Agriculture recounts the "tapado" system used by native people in Central America and Mexico. In those cultures, no-tillage methods are used and "seeds are thrown on top of the soil underneath a dense stand of vegetation. The plants are cut and left on top of the seeds. After a few days, the vegetation dries out and the seeds germinate and take roots." [75]



No-till farming **sequesters greenhouse gases.** For many years, discussions around global warming have been centered around the necessity to reduce greenhouse gas emissions. Some efforts have been made to try to absorb the carbon already present in the atmosphere, though no-till farming, which provides a critical answer, has not yet received the credit it deserves. A Rodale Institute report, Regenerative Organic Agriculture and Climate Change, explains that adopting regenerative agricultural practices such as no-till farming across the globe could sequester global annual greenhouse gas emissions representing 52 gigatons of carbon dioxide. [76]

HELPFUL, NOT HARMFUL, ADDITIVES

We can avoid the harmful effects of chemical pesticides and fertilizers easily by switching to regenerative alternatives that protect us and our the environment as well as crops. **Using bacteria, fungi, or parasitic insects that are native to an environment to act as natural predators of pests is much more effective and beneficial for the environment than chemical pesticides**. It is also a better economical choice, since it is very specific in the pests it targets, and it can create self-sustaining ecosystems that regulate themselves. [77]

Instead of chemical fertilizers, regenerative organic substitutes are a much better option for a multitude of reasons. **Using organic fertilizers results in increased carbohydrates in plants and the increase of beneficial soil bacteria. Organic fertilizers also often contain more iron, magnesium, and other nutrients for plants to absorb promoting health and resilience.** Animal manure is one of the most popular types of organic fertilizer, as it is effective, environmentally friendly, and economical. [78] Organic fertilizers improve crop yields, promote an overall healthier soil environment and greatly reduce the risk of nitrate leaching, the harms of which we discussed earlier. [79]

Biopesticides are also a great option to replace the usage of chemical pesticides. Biopesticides are made of naturally occurring materials found in different types of plants and animals. These types of pesticides control target species more effectively than chemical pesticides while keeping crop yield high. They have also been found to be significantly less toxic to wildlife and humans, and they decompose quickly minimizing accumulation in soils as well as runoff. [80]

CREDIT MATT GIBSON AND ERIN MARISSA RUSSELL

BARRIER CROPS

While the method of no-till agriculture is crucial to sequestering carbon, it is important for this system to be used along with other regenerative practices in order to be maximally effective against the threats of climate change. The use of barrier crops on farmland remains another essential part of regenerative agriculture.

According to the Encyclopedia of Entomology edited by John L. Capinera, **barrier crops, "...have been used as a cultural strategy for reducing pest populations for more than half a century. It involves establishing another minor crop on the perimeter of the main crop for pests and disease suppression.** Barrier crops reduce pests and related problems by acting as a physical barrier for vectors." [81] The wide majority of viruses that infect crops are spread by insects.

Aphids are the most common group of carriers of virus vectors. During feeding, aphids simultaneously ingest sap contents and inject saliva, which could contain viruses if the aphid had previously fed on an infected plant. There are two main categories of aphid transmission: non-persistent & persistent. Persistent viruses are retained by insect tissues and take several hours of feeding for an aphid to acquire a virus. Non-persistent viruses are capable of being transmitted by a vector, such as a biting insect or tick that transmits a disease, for only a relatively short amount of time. These types of viruses are retained in the piercing mouth part of the insect. [82]

Barrier crops focus on the spread of non-persistent aphid viruses by trying to prevent their presence on farmland. Those viruses account for approximately 50% of the 600 known virus vectors of carriers. [83]

In a study carried out in central Spain between 1995 and 1998, scientists investigated the "efficacy and mode of action of various barrier crops for reducing the spread of Potato virus and Y and Cucumber mosaic virus in pepper." The researchers concluded that there was a significant reduction in virus spread and an increase in yield in two of the four years of trial. The study demonstrated that the efficacy of this control strategy depends on a "series of factors such as the kind of virus spread pattern, the height of the barrier crop at the time of maximum risk of infection, and the extent of competition between the barrier and the protected crop." As a result, the researchers established that, under specific circumstances, **the use of barrier crops can be an effective control strategy to protect plants against virus infection**. [84]

Since no single method is likely to allow total control of diseases and parasites, other strategies such as cover crops can be integrated into regenerative farming in order to provide effective control.

COVER CROPS


Credit Ohio State University

Cover crops are plants used by farmers to slow erosion, improve soil health and fertility, enhance water availability, smother weeds, increase biodiversity, and more. **The Rodale Institute recognizes that "no-till systems can best reverse the trend of soil organic carbon losses in agriculture when they are complemented by cover-cropping and enhanced crop rotations. … At least half of the cropland carbon is fixed aboveground in plant biomass, making cover cropping and residue retention clear necessities for carbon sequestration."** [76]

Cover crops are planted in fields that would otherwise be bare in between growing seasons to protect the soil from erosion and nutrient loss. Like barrier crops, this method of farming also helps control pests and diseases on farmland. Depending on the species, cover crops have the ability to return nutrients to the soil, maintaining soil fertility without the use of harmful chemicals. [85]

The United States Department of Agriculture (USDA) claims that, "the protective canopy formed by a cover crop reduces the impact of raindrops on the soil surface thereby decreasing the breakdown of soil aggregates. This greatly reduces soil erosion and runoff and increases infiltration. Decreased soil loss and runoff translate to reduced transport of valuable nutrients. Over time, a cover crop increases soil quality by improving the biological, chemical, and physical soil properties." [86] Subsequently, the soil will become healthier by improving those properties.

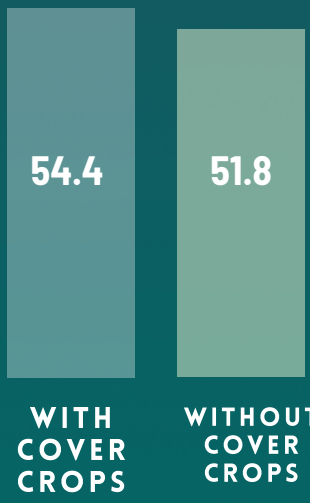
In a study conducted by Nakian Kim, Maria C. Zabaloy, and Kaiyu Guan, Do Cover Crops Benefit Soil Microbiome?, the researchers compiled the results of 60 relevant studies reporting cover cropping effects on soil microbial properties. They found that the practice of cover cropping "significantly increased parameters of soil microbial abundance, activity, and diversity by 27%, 22%, and 2.5% respectively, compared to those of bare fallow." This study demonstrated that the soil microbiome can become more robust under cropping "when properly managed with other agricultural practices." [87]

As a consequence, crops have shown to increase crop yield. After just one year of using cover crops, the yield benefit is often apparent for farmers. Other benefits such as improved soil fertility happen after several years of using this strategy. The USDA's 2019-2020 National Cover Crop Survey collected yield data which demonstrates that farmers can expect a 3% increase in their corn yield and a 5% increase in soybeans after five consecutive years of cover crop use. [88]

SOIL AGGREGATES

A combination of primary particles- sand, silt, and clay - that can be bound together and improve soil structure and health.

MEAN SOYBEAN YIELD



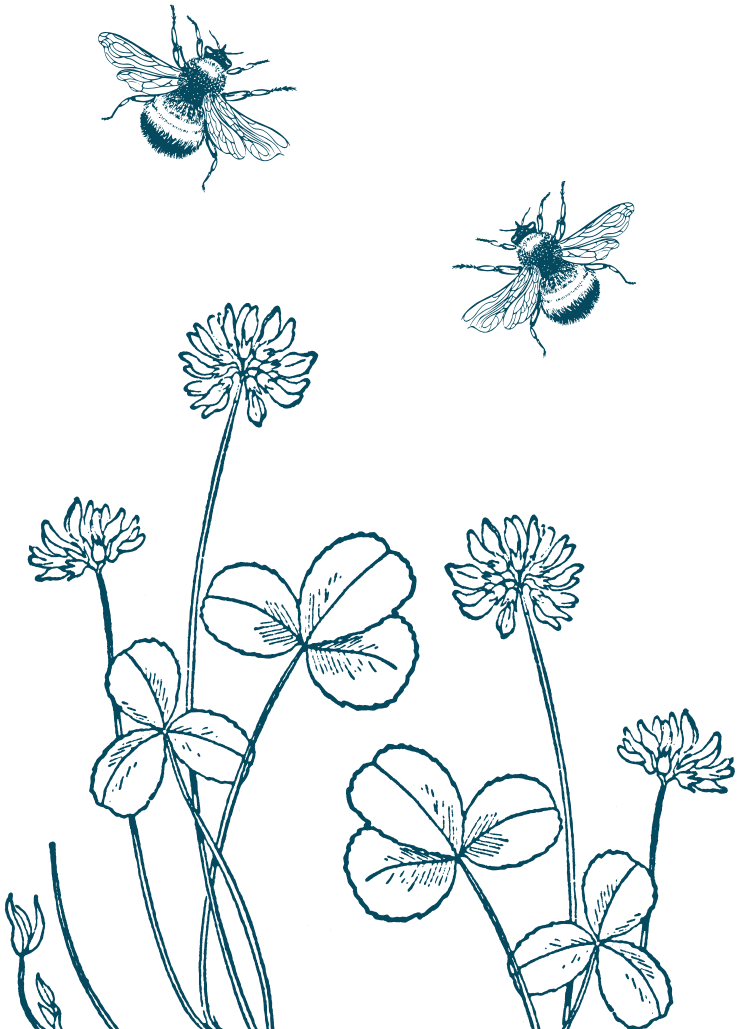
Graph credit Annual National Cover Crop Survey of 2020 : 2019-2020-National-Cover-Crop-Survey.pdf (sare.org)

According to the SARE bulletin Cover Crop Economics, “Cover crops should be viewed as a long-term investment that gradually improves farm management in multiple areas. Over time, this investment leads to lower costs and, sometimes, increased revenue.” It also reveals that “in some situations cover crops can pay off in year one, such as when they are used for grazing or to manage herbicide-resistant weeds. In other situations, such as when using them to alleviate compaction or to improve nutrient management, a payoff is more likely in the second or third year.” [89]

This sustainable technique has proved to improve crop diversity on farms and attract pollinators. In a 2014 study, author Katherine Ellis notes that “cover crops that have a flowering stage have the potential to support beneficial insect communities, such as native bees.” Considering the risk that bees are facing in the 21st century due to the destruction of ecosystems and agricultural intensifications, conservation of native bee communities is critical to maintaining free pollination and is economically beneficial to farmers. [90]

Cover cropping is an agricultural practice that has been used by North American native tribes for centuries, long before the first colonists arrived on the continent.

The Navajo Ethno-Agriculture group is a Native American non-profit dedicated to preserving the Navajo culture by teaching traditional farming. With more than 400 years of tradition, the Navajo People have a long history of farming practices that work in symbiosis with the ecosystem. Their relationship with the land is based on the premise of healthy soil where using cover crops is common practice. Through a desire to sustain traditional farming methods, the tribe has demonstrated a strong attachment to hands-on farming and the cultivation of chemical-free, traditional Navajo crops. [91]



PLANT & ANIMAL DIVERSITY

Livestock and agricultural crops have co-existed together for millennia where animals roamed freely around the farmland. The increasing industrialization of farming, though, has physically separated animals from crop production. In the 1800s, farmers began fencing in their livestock. Beginning in 1920, poultry became the first large-scale farmed animal. [92]

Since then, new methods have been developed to try to bring back a more beneficial and ethical way of animal farming. One of those solutions aims to re-introduce livestock to agricultural crops instead of keeping them separate. This creates mutualism between crops and livestock benefitting both sides. Animal grazing after crop harvest helps in the conversion of high carbon residues to low carbon organic manure (animal dung used for fertilizing land). [93] Grazing on cover crops allows more nutrient cycling from crop to soil and carbon sequestration into the soil. Additionally this practice mitigates the challenges and risks associated with concentrated animal feeding operations such as disposal of animal wastes, water quality, animal health, and risks of contaminating watersheds.

According to the US Department of Agriculture, during fall or winter seasons livestock can be returned to the landscape “to convert high carbon annual crop residue to low carbon organic material; balancing the carbon/nitrogen ratio and managing our crop rotation residue for no-till seeding.” During spring or summer, animal grazing “allows the plants to regrow and harvest additional sunlight and CO2.” Further, livestock can “manage weed pressure by grazing in lieu of herbicide”, and “grazing reduces livestock waste associated with confinement; helping manage water quality and nutrient management concerns.” [94]

EDUCATION AND RESOURCES

ED FOR YOUTH!

To tackle immense issues like **climate change** and degenerative agricultural practices, our generation needs the opportunity to learn about the challenges we are inheriting, **collaborate** with one another as we process solutions, and develop critical thinking and empathetic leadership skills. **Education reform** is essential, as schools must evolve to better prepare youth for the changing and degraded environment in which we will live, as we are the **next generation of decision-makers.** Heirs To Our Oceans utilizes a project-based learning model through its programs, including the Regenerative Agriculture and Indigenous Systems for our Environment (RAISE) initiative. Having real-world, hands-on learning opportunities for youth will allow them to become informed and prepared and to connect with their natural environment – one protects what they love, and they love what they connect with.

ED FOR FOOD GROWERS!

Accessible, available educational programs for farmers are necessary as they transition to regenerative agriculture. The Rodale Institute has a **Farmer Training Program** as well as webinars, workshops, online courses, [95] and farm consultation opportunities. The Regenerative Agricultural Alliance [96] aims to assist in increasing regenerative agricultural practices that are being implemented and is made up of a diverse group of farmers, tribes, businesses, and more. Another resource for farmers is the Farmer's Footprint [97], a coalition of farmers, educators, scientists, and other stakeholders who are working to address the public health and environmental impacts from chemical farming while moving towards a large-scale regenerative model.

The **Cultural Conservancy** based in the San Francisco Bay Area is a native-led organization working to protect and restore Indigenous practices, including Indigenous food knowledge offering educational programs and hands-on experiences. [98] Through workshops, training sessions, and a design course, the Traditional Native American Farmers Association supports indigenous farmers revitalizing their agricultural practices for spiritual and human needs. [99] They include both farmers and youth in the conversation to ensure a healthy future for all. Tackling this issue through policy is vital to protecting our planet for future generations.

RESOURCES FOR FARMERS!

In California, the Healthy Soils Program Incentives Program "provides financial incentives to California farmers and ranchers to implement conservation management practices that sequester carbon, reduce greenhouse gases, and improve soil health." [100] For farmers across the country, the Biomass Crop Assistance Program (BCAP) "provides financial assistance to farmers, ranchers, and private rural landowners who wish to establish, produce, and deliver biomass feedstocks which is a renewable energy source." [101] Conservation Innovation Grants (CIG) are grants for both public and private sectors in an effort for resource conservation through "creative problem solving" that increases agricultural production while simultaneously improving "water quality, soil health, and wildlife habitat." [102]

TRAININGS

Looking to expand your understanding of soil science or looking to implement regenerative biodynamic farming practices? Check out these programs!

Drawdown Action Resources – Urban Drawdown Initiative
Regenerative Agriculture Academy Courses – Regen Ag Academy
Organic Farming Training – Rodale Institute
Agriculture Supported Communities Training Program – Rodale Institute
Biodynamic Farmer Training – Biodynamic Association
Permaculture Design Certification Courses – Google courses in your area!
Farming Immersion – Soul Fire Farm
Uprooting Racism Training – Soul Fire Farm

ED FOR EVERYONE!

Interested in finding regenerative farms near you so that you can support their sustainable practices? Regenerative International created a **farm map** to showcase farms around the world that have shifted to these better practices. [103]

For those who want to learn more about the state of policy around soil in the United States, **Soil Policy Action** has resources to learn more about regenerative agriculture along with ways to take action. [104] A map highlighting healthy soil policy in each state is also available. [105]

Independent organizations addressing regenerative agriculture are sprouting up all around the world. One such organization is Regeneration International established in 2015 and made up of a diverse group of scientists, business owners, farmers, educational institutions, policymakers, and NGOs, with the common goal "to reverse global warming and end world hunger by facilitating and accelerating the global transition to regenerative agriculture and land management". [106] Another is Kiss the Ground, a documentary and a non-profit organization working to rebuild healthy soil in an effort to reverse climate change through education, campaigns, and media. [107]

Many more independent organizations are joining the effort toward the shift to traditional ecological farming practices, or regenerative agriculture. Keep and eye out and support them!

LEGISLATIVE EFFORTS

There is existing legislation pertaining to regenerative agriculture introduced by congresspersons from across the country, which may be a good starting point for a positive transition. However, in order to make serious progress to meet urgent need, this legislation will need to be greatly reinforced and expanded upon.

Joe Neguse, a United States Congressman from Colorado, introduced his bipartisan regenerative agriculture proposal which includes the Study on Improving Our Lands (SOIL) Act calling for the study of soil health on federal lands and recommendations for legislation to "improve soil health, increase carbon sequestration, and improve community benefits of soil health programs." These studies must include "analysis of the impact that grazing, wildfire, recreation, and invasive species have on soil." [108]

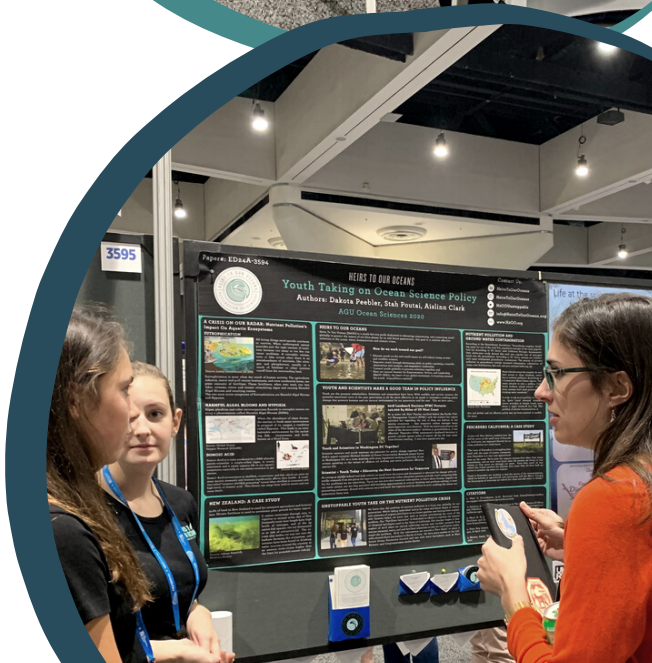
Congressman Neguse also introduced the Sustainable Agriculture Research Act which expands the goals of the Agriculture Advanced Research and Development Authority (AGARDA) to "enhance the role of agriculture in innovative voluntary resilience solutions in the United States through the development of agricultural technologies that address the impact of extreme weather on crop production, the expansion of the potential for long-term carbon storage through agriculture, increased economic and practical feasibility for renewable and sustainable energy on farms and in the agriculture industry, and increased adoption of voluntary conservation practices that sequester carbon and build on-farm climate resilience." [109]

The Select Committee on the Climate Crisis created a Climate Crisis Action Plan to “provide a roadmap for Congress to build a prosperous, clean energy economy that values workers, advances environmental justice, and is prepared to meet the challenges of the climate crisis” released in June of 2020. [110]

The Agriculture Resilience Act (ARA) was introduced by Chellie Pingree, a congresswoman from Maine, and was designed to provide farmers with the resources to meet the goal of reducing agricultural emissions by 50% before 2030 and become net-zero by 2040. [111]

In the future, more comprehensive plans will need to be realized in order to eliminate the GHG emissions agriculture can generate and the phalanx of negative impacts being felt by communities here in the US and around the globe.

For those who want to learn more about the state of policy around soil in the United States, Soil Policy Action has resources to learn more about regenerative agriculture along with ways to take action. [104] A map highlighting healthy soil policy in each state is available. [105]



BENEFITS AND CHALLENGES OF REGENERATIVE AGRICULTURE

Transitioning industrial systems to sustainable practices and supporting current regenerative efforts benefits everyone in varied and exciting ways.

However, there are also challenges with implementing regenerative systems that need to be acknowledged and addressed in order for us to act effectively and cooperatively.

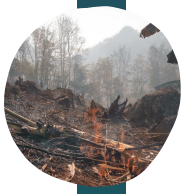
Following is a summary, from our perspective, of just a few of the many benefits and some potential challenges of implementing regenerative systems.*

BENEFITS

Climate: Regenerative agriculture, on a larger scale, is a solution to the climate crisis before us, as is conscientious livestock management.

Soil Health: Regenerative agriculture actively benefits topsoil health. [112] It naturally and sustainably increases the overall health of the soil ensuring continuous harvests with nutritious benefits for humans. [113]

Farmers Profit: Regenerative agriculture benefits farmers' livelihoods by ensuring arable land in the long term and attracting environmentally-conscious buyers. Many farms have seen up to substantial increased profitability when going regenerative.



Crop Resilience: Traditional food growing methods produce crops that are more resilient to harsh weather conditions and diseases, as diseases are naturally displaced and suppressed beneficial soil microbes. Diverse crop rotations on farms can also help lower the number of pesticides used and reduce the loss of crops to disease, as diverse crops minimize the impact when one crop is hit hard by a disease or pest it's especially vulnerable to.

Improved Livestock Management: Aside from the ethics of healthier lives for livestock, managing livestock in regenerative ways perpetuates nutrient cycling, reduces the waste associated with manure buildup, and can facilitate plant growth and carbon sequestration.

*

We would like to thank Mason Jones, 14 years, for his contribution to this section of the Paper.

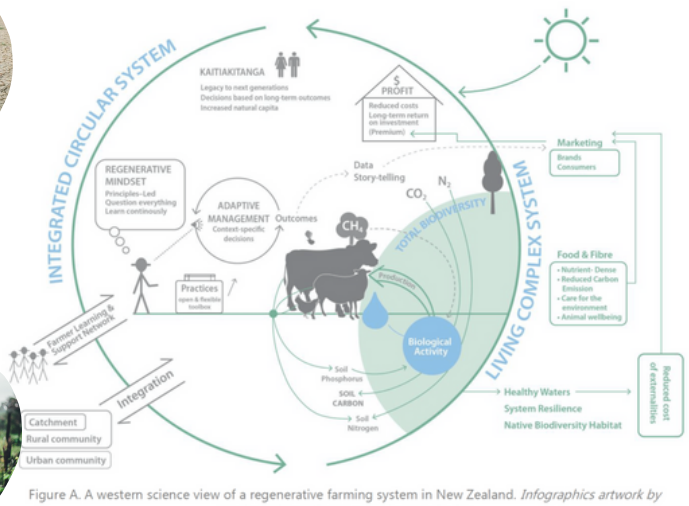


Figure A. A western science view of a regenerative farming system in New Zealand. *Infographics artwork by Marion Millard-Grelet and Nicolette Faville.*

Improved Water Quality: Traditional, regenerative agricultural practices significantly reduce water quality issues in agricultural communities and in water bodies, including coastlines and lakes, by reducing runoff produced by the overuse of synthetic and chemical fertilizers. Marine life and marine ecosystems are severely affected by synthetic and chemical run-off. Reduced tilling and the use of cover crops also minimizes soil erosion, while good grazing practices can increase vegetation and protect water sources.

CHALLENGES

Transition Period: The initial transition from degenerative to regenerative agriculture may create a challenge for conventional farmers including a switch of equipment and practices. In an effort to support this essential transition, state and federal governments should ensure adequate resources are set aside. Sufficient education and resources for farmers to learn about regenerative practices and how to transition must be readily available. Grants, investments, and subsidies can be directed to smaller-scale, community and health-oriented farmers.

Lack of Existing Regulation: Certification and definition for regeneratively produced products must exist federally. A lack of criteria might prove an obstacle for effective legislation that incentivizes regenerative practices. Safeguards would need to be put into place peremptorily as corporate patterns and practices in the last decade show "greenwashing" tactics.

"Greenwashing" is where a business engages in intentionally misleading marketing leading consumers to view an unsustainable product as environmentally friendly. Corporate and industrial farms may engage in greenwashing by calling their products "regenerative" without practicing truly sustainable farming in an attempt to receive superfluous financial assistance and increase profits trying to appeal to eco-conscious buyers. To allow industrialized corporate agriculture businesses to access money available to farmers authentically in need of financial support in creating a sustainable food growing practice would be unconscionable and work directly against achieving a safe world for our generation and the next generation.

Lack of Representation: One problem with the regenerative agriculture movement is the lack of representation and the cultural theft of indigenous people. [114] Persons who are Black, Indigenous, and other People of Color have been historically neglected by the US government in agricultural (and other) spaces. These peoples, many of which are currently living in urban and reservation food deserts, are in need of recognition, acknowledgment and support in growing healthy food.

DESERTIFICATION

The process by which fertile land becomes desert, typically as a result of drought, deforestation, or harmful agriculture.

THE PATH FORWARD

The climate crisis is here.

Our generation has seen the fires, floods, droughts, depleted soils, displacement and food insecurity that results from, or is exacerbated by, the anthropogenic changing climate. We do not know what kind of world we will be leaving behind for the generations that come after us, but we youth do know one thing: **Every action we take today will influence what our world will be, and it is imperative that we do everything we can to provide a healthy, livable future for our children and our children's.**

For regenerative agriculture to be a viable solution to the climate crisis, we must take action now.

Education is essential.

Both in and out of school, youth everywhere must learn and be equipped to discuss science, policy, food and water security, intersectionality and environmental justice.

We must work toward good governance everywhere.

Demanding policies that prioritize and protect us, our land, and life-supporting ecosystems, and which assists farmers in transitioning to traditional, healthy, regenerative agriculture practices, is required. Good governance involving empathetic leaders must become the norm to achieve a safe world for the majority, not just the privileged few.

We must hold Big Ag corporations accountable.

Corporations that harm our natural environment and people for short-term profits can no longer continue to do so. They must be held accountable for their contribution to the climate crisis and to their responsibility to our planet and our future.

We must hold ourselves accountable.

As best we are able, our food purchased should be from farmers who grow locally with regenerative agricultural practices, supporting food growing that nourishes our bodies and our soils.

We in industrial societies must make dedicated efforts to nurture our relationship with the land. Connection with nature, with our food, and with each other are essential steps toward a future of regeneration.

It is up to us to
mitigate the climate crisis,
grow healthy food,
nurture our soil,
protect our water, and
feed each other.

Regenerative agriculture
is a powerful and scalable solution
for our generation and our kids'.

THE RAISE TEAM

PROFESSIONAL CONTRIBUTORS

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