CAN SOIL SAVE US?

Making the Case for Cover Crops as Extreme Weather Risk Management

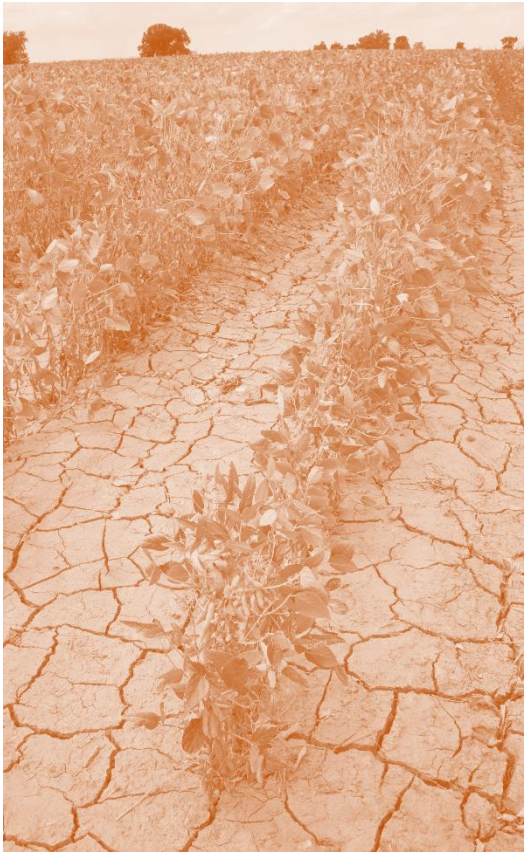
P.A. White

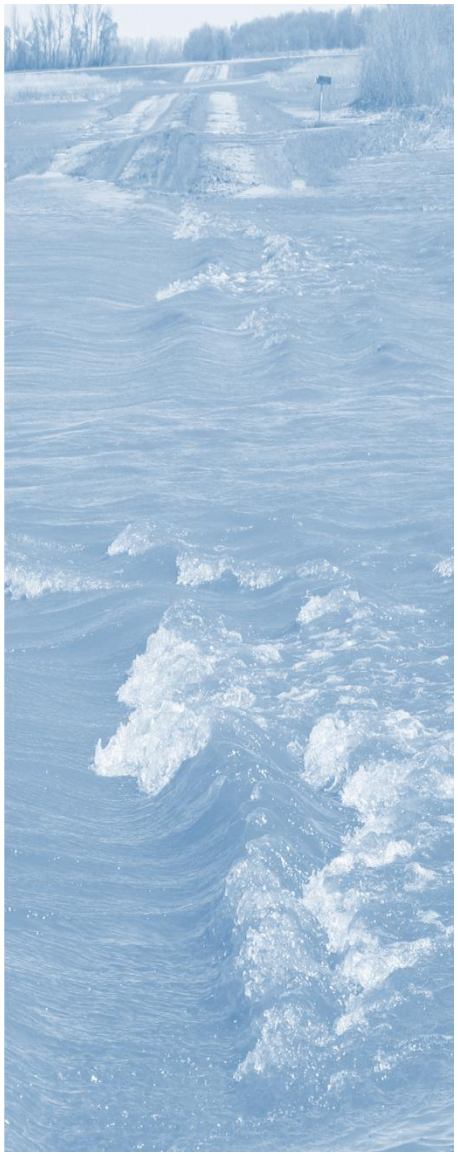
June 2015

NATIONAL WILDLIFE FEDERATION

Acknowledgements

The author wishes to thank the many people who generously contributed to the development of this report: Lara Bryant, Sarah Carlson, Paul Gross, Rob Myers and Jill Sackett. Also, the efforts of the agriculture and communications teams are greatly appreciated: Julie Sibbing, Ryan Stockwell, Linda Argueta, Miles Grant.





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EXECUTIVE SUMMARY

According to the National Climate Assessment, climate change is **increasing the frequency and intensity of extreme weather events** such as droughts, storms, floods and wildfires nationwide. About two-thirds of the continental United States was affected by drought in 2012, impacting water supplies, tourism, transportation, energy, fisheries and agriculture. Recent **droughts** in the south and Midwest set records for highest monthly average temperatures and the number of heat waves is now triple the long-term average. Prolonged drought is unprecedented since the start of reliable instrumental records in 1895. **Extreme precipitation** events are also becoming heavier and more frequent. Since 1991, the amount of rain in heavy downpour events has been significantly above average – most evident in the Northeast, Midwest and upper Great Plains – more than 30 percent above the 1901-1960 average.

Soil degraded by decades of mechanized farming is particularly vulnerable to drought and flood. Unhealthy soil is dry and compact, devoid of not only moisture but organic matter, crippling the soil's natural abilities to respond to stress and exacerbating the negative impacts of the event. During drought, what little moisture remains in the soil is lost quickly. During flood, excess water runs off compacted soil rather than infiltrating. Producers lose crops and livestock and often lose equipment and facilities during flood. As a result, rural communities that depend on agriculture are devastated by extreme weather events. The 2012 drought cost the agricultural sector alone more than **$30 billion**. Consumers and taxpayers also feel the heat through higher food prices and heavily subsidized crop and flood insurance.

Americans also spend a great deal of resources on public and private efforts to **plan** for and **respond** to extreme weather events. Government is involved from Pennsylvania Avenue to Main Street, funding everything from research to relief. Scientists are mapping and modeling weather patterns to predict extreme weather events, while engineers are building dams and levees to protect communities.

Unfortunately, the majority of our current extreme weather event spending and policy is more **reactive** than proactive, falling into a plan, predict, respond and recover pattern. While we cannot prevent drought and flood, **there is more we can do** to prepare beyond predictions and flood proofing.

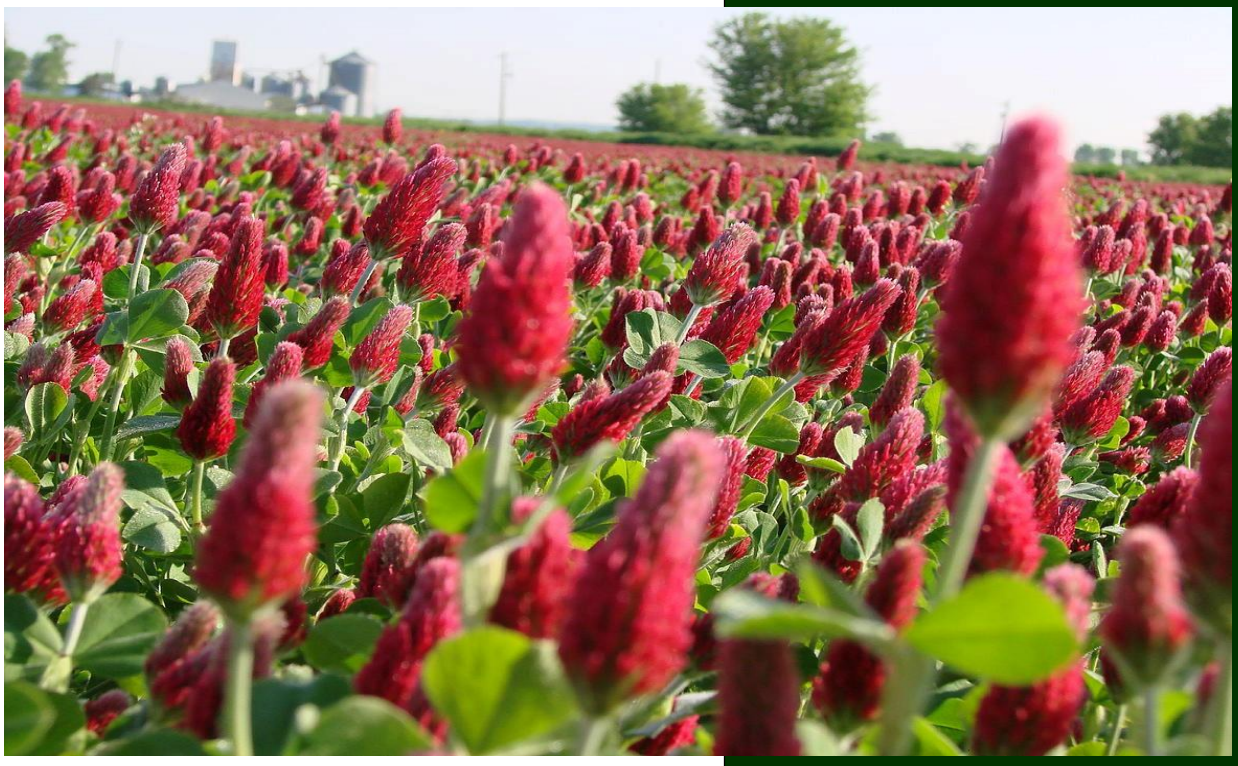
Can Soil Save Us? This report hopes to demonstrate that for a fraction of the resources now devoted to extreme weather planning and response, America could be wisely **investing in improving our soil health** by promoting sustainable agriculture practices such as cover crops. In addition to all the ancillary benefits of sustainable agriculture – reduced erosion, increased nutrient retention, lower input costs – healthy soils are better able to withstand the impacts of extreme weather events.

HEALTHY SOIL IS RISK MANAGEMENT.

What is a cover crop?

Most people are familiar with the concept of a crop: farmers plant cash crops one season and harvest in the next. **Cover cropping** is the practice of planting a second, unharvested crop in coordination with the cash crop to prevent wind and water erosion, reduce nutrient loss and leaching and improve soil health and quality. Farmers grow cover crops in a variety of ways, including growing them year round as a living mulch, planting after harvest or intercropping by growing the cover between rows of the cash crop. While not harvested, cover crops can be grazed or mowed for forage.

Throughout agricultural history, farmers have taken advantage of the many benefits of using cover crops. During the Roman Empire, Greek and Roman farmers used legume cover crops to improve soil quality in their vineyards. In the late 1700s, lupines were used throughout northern Europe to improve sandy soils. By the 1860s, cover crops were common practice in American agriculture and remained so until the 1950s.



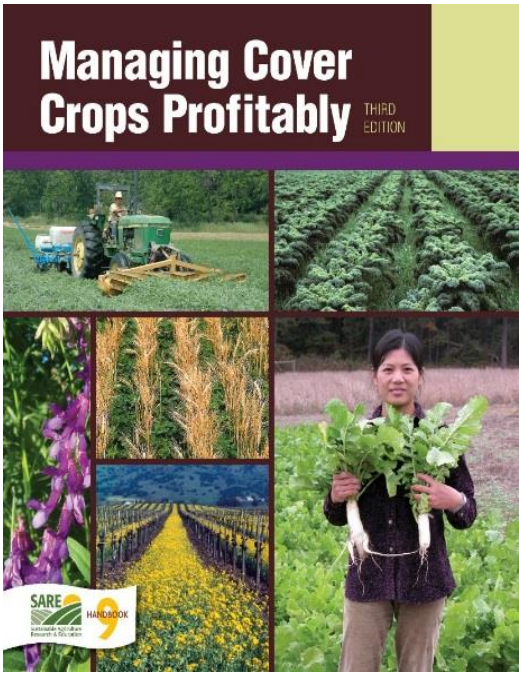
Cover cropping was largely abandoned by the late 1950s when conventional agriculture turned to synthetic **fertilizers**.[i] Readily available and comparatively inexpensive, synthetic fertilizers replaced cover crops for enhancing soil fertility and significantly changed how cropland was managed. Today's generation of farmers grew up with widespread use of fertilizers and herbicides and little or no understanding of cover crops.

In the United States, increased fertilizer use and soil erosion have taken a toll on our environment. In the 2000 National Water Quality Inventory, states reported that agricultural nonpoint source (NPS) pollution was the leading source of water quality impacts on surveyed rivers and lakes, **the second largest source of impairments** to wetlands and a major contributor to contamination of surveyed estuaries and ground water.

Reaching the end of the 20th century, the burgeoning environmental movement led to a growing interest in **sustainable agriculture**, based on modern ecology. Minimum and no-till farming, crop rotation and integrated pest management became more common. Congress and USDA caught up by offering programs such as the Conservation Reserve Program and Sustainable Agriculture Research and Education (SARE).

According to the Sustainable Agriculture Research and Education program's (SARE) successful book, "Managing Cover Crops Profitably," cover crops provide both economic and ecological benefits such as:

1. Reduce fertilizer costs
2. Reduce the need for herbicides and other pesticides
3. Improve yields by enhancing soil health
4. Prevent soil erosion
5. Conserve soil moisture
6. Protect water quality
7. Help safeguard personal health



MAKING THE CASE FOR COVER CROPS AS EXTREME WEATHER RISK MANAGEMENT

Cover crops help **improve soil health** by reducing compaction, increasing water filtration and retention and improving soil organic matter. Much like a healthy person having a stronger immune system, healthy soil is less susceptible to impacts from extreme weather events and better able to recover after.

First, healthy soil can prevent flood damage. Unlike degraded and compacted soil that promotes runoff, healthy soil can soak up and retain large quantities of water like a sponge. USDA reports that for each 1 percent increase in organic matter, our cropland could store the amount of water that flows over Niagara Falls in 150 days.[ii] Water that is trapped in farmers' fields won't be flooding streets, houses and schools.

Second, healthy soil will protect the individual farmer and the rural community in the affected area. If farmers are better able to withstand the drought or flood, they will lose fewer crops, livestock, equipment and facilities. When those farmers are able to stay financially afloat, all the residual businesses around them – from grain elevators to grocery stores – will also survive.

Finally, healthy soil can save consumer and taxpayer dollars. When crops are lost to extreme weather events, consumers pay the price. Also, farmers rely on taxpayer subsidized crop insurance and emergency relief funding to cover losses from drought and flood.

BENEFITS	HOW BENEFIT MITIGATES DROUGHT AND FLOOD IMPACTS
REDUCE COMPACTION	Heavily tilled, dry soil becomes hard and compacted as much as 8-12 inches below the surface. Compacted ground prevents roots from accessing soil moisture and nutrients at great depths, forcing them to rely strictly on rainfall or irrigation and applied fertilizers. The roots of cover crops can break through compacted soil, creating a soil more accessible for the cash crop, even in dry years.
INCREASE WATER FILTRATION	Dry, compacted soil doesn't allow water in, forcing water to flow across fields rather than into the soil where it is needed for use by plant roots. These conditions are not only bad for soil and crops, they exacerbate flood events because excess water has nowhere to go. Cover crops increase water filtration, allowing more water to enter the soil. Roots create spaces that hold water, decreasing the need for irrigation and reducing susceptibility to drought. Those spaces also act like pores of a sponge, absorbing more excess water during flood events.
INCREASE WATER RETENTION	During drought, any moisture that is left in the soil is lost to evaporation. Living cover crops act as shade trees, keeping soil temperatures lower and shielding fields from direct sunlight. When cover crops are terminated, a mat of cover crop debris is left behind on the soil's surface, further reducing evaporation during hot weather.
REDUCE EROSION	Bare farm fields are susceptible to erosion from both wind and water. Without the valuable layer of topsoil, eroded fields are more vulnerable to the impacts of flood and drought. Cover crop plants protect the top soil and the roots anchor the soil below the surface, preventing erosion. The aboveground part of the plant cushions the impact of heavy rains and slows water movement, while its roots bind the soil and form "pores" through which water drains, reducing runoff.
IMPROVE SOIL ORGANIC MATTER	Conventionally tilled fields lose soil structure and organic matter. Soils with low levels of living, organic matter are more vulnerable to the impacts of flood and drought. When cover crops are terminated, the plant residue left on the field turns into nutrient rich organic matter in the soil, while plant roots loosen the soil, allowing for increased biological activity in the soil.
NUTRIENT SEQUESTRATION	Bare fields are more likely to lose the residual nitrate remaining in the soil after harvest. Numerous studies have shown the highest N losses in drainage waters after dry years. Nitrate will leach out the bottom of the root zone from rainfall during fall through spring, washing into local waters and eventually rivers. Cover crops are able to scavenge residual N and recycle it, as the roots and shoots decompose after termination, the N taken up by the cover crops is released for use by the cash crop and support soil organic matter. Cover crops can reduce nitrate leaching between 40 and 70 percent compared with bare soil.
GRAZING	During drought years, permanent pastures are often too dry to sustain herds. Livestock producers have to pay for hay or other stored forages to feed their cattle, sheep or other ruminants. Hay and corn silage may be in short supply and/or very expensive. With limited feeding options, many dairy and beef producers have to liquidate their herds. Cover crops offer great potential for dual use to provide valuable forage for livestock without losing the soil improvement benefits. Using cover crops for fall and winter grazing can not only carry livestock through drought events, many producers report impressive weight gain when grazing their animals on cover crops over the winter.

PURDUE UNIVERSITY

Following the drought of 2012, Purdue Department of Agronomy's Eileen Kladivko recommended cover crops as a good investment for farmers to benefit their farms and regional water quality. Specifically, Dr. Kladivko points to the residual nitrate remaining in the soil at harvest time that will leach out of the root zone over the winter. "Cover crops are an excellent practice to scavenge residual N and recycle it through their plant biomass (shoots and roots)," she says. "As the cover crops decompose next year, some of the N taken up by the cover crops will be released for use by the next cash crop, and some will go towards building soil organic matter."[iii]

NRCS/UNIVERSITY OF MISSOURI

The Natural Resources Conservation Service awarded a Conservation Innovation Grant to Tim Reinbott at the University of Missouri for his project to increase farmers' understanding of the effects of management practices (such as cover crops) on soil health, water capacity and infiltration. Reinbott uses field days, workshops, clinics and a mobile demonstration soil health trailer to reach farmers. "The concept of soil health and quality and how it relates to tolerance for drought is new to a lot of our landowners. Thanks to NRCS and the grant, we can make sure farmers and ranchers are better equipped to handle drought," said Reinbott.[iv]

AMERICAN JOURNAL OF ALTERNATIVE AGRICULTURE

In their 2003 article, "The performance of conventional and organic cropping systems in an extreme climate year," Lotter, Seidel and Liebhart covered the results of a 21 year Rodale Farming Systems Trial, and concluded that soils with higher water holding capacities is the major important factor in increasing drought tolerance and higher yield during water deficits.[v]

BURLEIGH COUNTY SOIL CONSERVATION DISTRICT

Menoken Farm is a 150 acre educational site in Burleigh County, North Dakota where average annual rainfall is just 16 inches. In 2006, NRCS started replicated trials of eight different species of cover crops. One test plot contained a monoculture and all other plots contained various combinations of mixes from two species to eight species. After one of the driest years on record, the monoculture failed and the lower diversity mixes suffered, but the eight species mixture was not stressed and actually produced healthy yields despite the drought conditions. Rather than competing, the eight species create a diverse subterranean ecosystem, making soil resilient, fertile and drought resistant.[vi]

USDA SUSTAINABLE AGRICULTURE RESEARCH AND EDUCATION (SARE)

Following the 2012 drought, USDA SARE sponsored a cover crop survey designed and distributed by the Conservation Technology Information Center and Midwest Cover Crops Council. Farmers were asked questions regarding cover crop adoption, benefits, challenges and yield impacts. They found that soybeans planted after cover crops had a 11.6 percent yield increase compared to adjacent fields without cover crops, and corn after covers increased 9.6 percent. Where the drought hit hardest in the Corn Belt, yield boosts were even greater with 14.3 percent for soybeans and 11 percent for corn. Dr. Rob Myers, a University of Missouri agronomist and North Central Region SARE's director said, "It is especially noteworthy how significant the yield benefits for cover crops were in an extremely dry year."[vii]

UNIVERSITY OF MINNESOTA

In 2005, a team of researchers evaluated possible changes to current farming practices in two Minnesota watersheds, seeking farm policy improvements with positive environmental, social and economic outcomes. Models indicated that decreasing runoff in agricultural landscapes by 10 percent within a watershed can reduce flood peaks with a 2- to 5-year return by 25 percent to 50 percent and may reduce a 100-year flood by as much as 10 percent.[viii]

TOMMY HENDERSON, CLAY COUNTY TEXAS

In the midst of one of the worst ongoing droughts in Texas history, Tommy Henderson added summer cover crops to his farm management program. Neighbors scoffed at planting a summer crop during a drought, believing it will use what little moisture remains in the soil. However, Henderson's experience shows that while a cover crop does use some of the soil moisture, it actually protects soil and helps retain more moisture. With temperatures topping 110 degrees, soil temperatures can reach over 150 degrees, killing healthy soil bacteria and microorganism that feed crops. Cover crops shade the soil and reduce evaporation while roots create pores to draw precious rainfall deep into the soil. Even with half the average rainfall, Henderson's wheat crop survived while others failed. "You can't buy rain," Henderson said. "So the fact the cover crop is why my wheat crop has access to moisture in the middle of a drought is a big deal."[ix]

DANIEL STEIDINGER, ILLINOIS

Wanting to increase water filtration in fields where soil was severely compacted, Steidinger began planting radishes as a cover crop. Radish roots break up compacted soil, pulling water deep into the soil profile rather than allowing it to run off the surface, taking precious topsoil and nutrients along. Rather than suffering from the drought, he and his neighboring farmers using cover crops survived. "There was a 100 bushel difference in my field with cover crops," Steidinger said. "And in a drought like we had, that just speaks for itself."[x]

BRENDON ROCKEY, COLORADO

Rockey Farm grows 30 varieties of specialty potatoes on 500 acres in Colorado's San Luis Valley. Concerned about the poor condition of the soil in the 1990s, they began using cover crops to reduce compaction and increase organic matter. After 20 years of cover crops, the soil at Rockey Farm is healthy again. Even in an arid region that receives seven inches of rainfall, and despite the drought affecting the west, their yields and profits have improved. "When we irrigate, more water stays in our fields instead of running off," Brendon Rockey said. "It isn't that my plants need less water; my potato plants are essentially the same as my neighbors'. My soil is what's different, acting like a sponge instead of a stone."[xi]

GABE BROWN, NORTH DAKOTA

In 2013, Gabe Brown's 5,400 acre farm located east of Bismarck, North Dakota stayed green, even after 70 days with less than half an inch of rain. As soil organic matter increases from 1 percent to 3 percent, the water holding capacity doubles. More than two decades of no-till and cover crops improved the organic content of his soil to hold roughly three times as much water as a conventional operation. "It's not how much rainfall you get," Brown said. "It's how much you can store." Brown's soil is also prepared for too much rain. After 13 inches of rain fell in 24 hours, his low lying fields had no standing water while his neighbors were flooded.[xii]

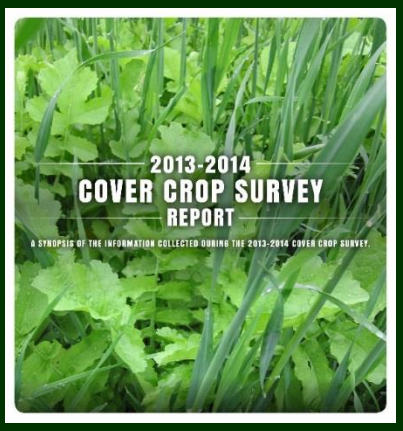
DAVE BRANDT, OHIO

On his 1,200 acres in Carroll, Ohio, Dave Brandt – dubbed the "Obi-Wan Kenobi of Soil" by local NRCS agents – has been using no-till since 1971 and cover cropping for decades. His crop yields generally exceed the county average and even during the drought of 2012, his yields were near the normal season average while his neighbors suffered 50 percent drops in yield or lost their crops entirely.[xiii]

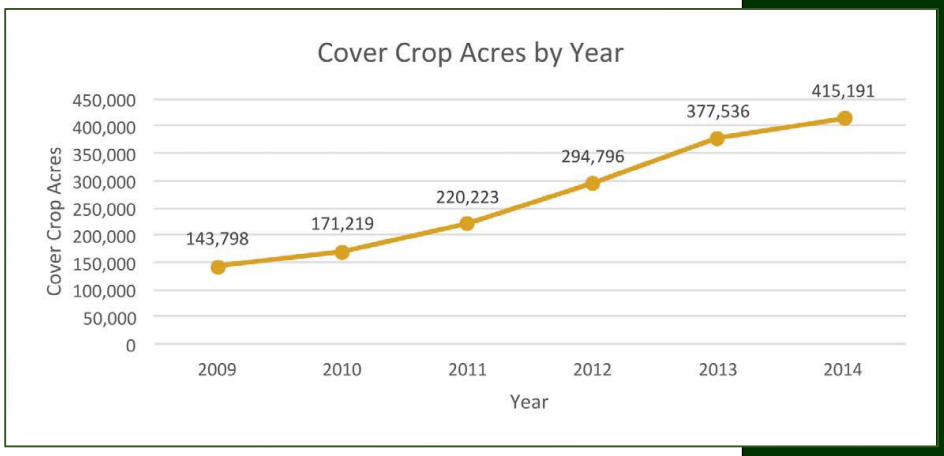
LADDER RANCH, WYOMING

Sharon and Pat O'Toole raise cattle, sheep, horses and working dogs on 600 acres of irrigated land in the Little Snake River Valley. Like many ranches in the west, the O'Tooles rely on water derived from melting mountain snowpack. Part of their holistic management is using cover crops and rotational grazing, allowing grasses time to regenerate while building soil organic matter. Even in a changing climate, with less reliable snowpack and inconsistent water supply, the Ladder Ranch is thriving.[xiv]

GROWTH OF COVER CROP ADOPTION



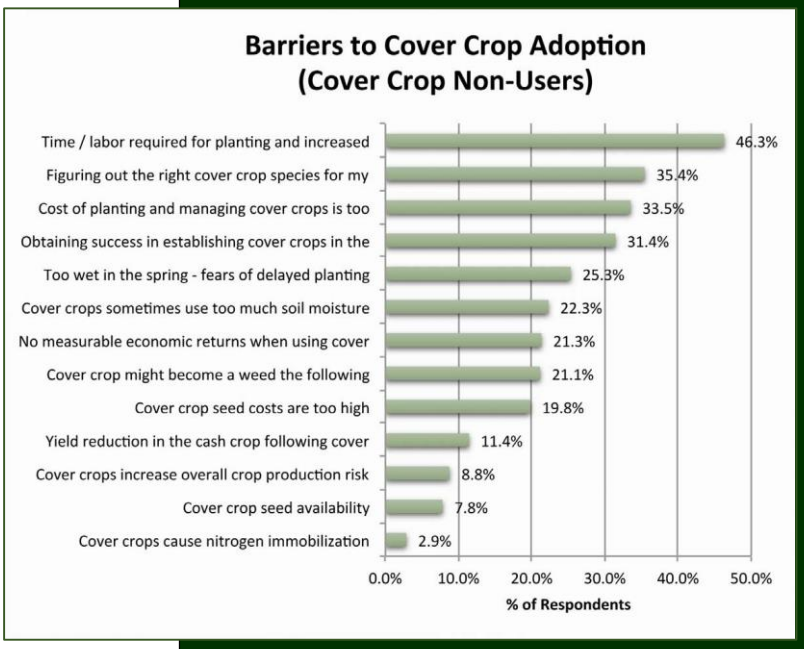
Starting in 2012, the North Central Region Sustainable Agriculture Research and Education (SARE) and Conservation Technology Information Center (CTIC) conducted surveys of farmers to document cover crop use. The number of growers utilizing cover crops and the percentage of total acres planted to cover crops have been on the rise since 2009.



While the numbers are growing, the amount of farmland under cover crops remains too small to show significant drought and flood mitigation and recovery benefits. Despite the many benefits of adding cover crops to their rotations, many farmers have yet to adopt the practice due to barriers, both real and perceived.

The SARE/CTIC survey also asked non cover crop users why they have not yet adopted the practice. The top three challenges cited were:

1. Not enough time/labor to plant cover crops
2. Insufficient knowledge regarding which cover crop species to use and
3. The cost of planting and managing cover crops



THE SCIENCE OF DROUGHT AND FLOOD

Extreme weather events such as drought and flood are often called “natural disasters.” Half of that moniker is accurate – they are natural. In fact, drought and flood are not only part of the natural order, they are necessary aspects of the ecological processes that create and maintain our ecosystems.

However, these extreme weather events are often devastating at the individual farm level, and expensive for producers, consumers and taxpayers. While we can’t prevent extreme weather events, we can better prepare for and respond to them. But first, we must understand them.

DROUGHT 101

When we think about drought, we imagine dried and cracked ground, windswept deserts and widespread starvation. Not all drought is that drastic, but unfortunately, droughts are becoming more common and more **severe**.

According to the National Oceanographic and Atmospheric Administration (NOAA):

> *Drought is a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people. It is a normal, recurrent feature of climate that occurs in virtually all climate zones, from very wet to very dry. Drought is a temporary aberration from normal climatic conditions, thus it can vary significantly from one region to another. Drought is different than aridity, which is a permanent feature of climate in regions where low precipitation is the norm, as in a desert.*

Drought conditions are often **exacerbated by human demands** creating additional stressors on water resources, such as water contamination, growing populations, and increased water use and waste. A 50 percent increase in the Southeastern states' population – creating unsustainable demands on the water supply – was blamed for the severe drought that seized the region from 2005 to 2007.[xv]

But it's all relative. What would be considered a drought in one place would be the norm in another. So scientists developed the **Palmer Drought Severity Index (PDSI)** to classify droughts by consolidating several factors – temperature, precipitation, evaporation, transpiration, soil runoff, and soil recharge data – into a single negative number that serves as an estimate of soil moisture deficiency and thereby the impacts of a drought.

The Palmer Drought Severity Index (PDSI) takes regional variance into account and is used to categorize droughts into levels of severity:

-1 to 1.9	abnormally dry
-2 to -2.9	moderate drought
-3 to -3.9	severe drought
-4 to -4.9	extreme drought
-5 to -5.9	exceptional drought

For example, 20 inches of rainfall in a year is normal in West Texas, and would correspond to a Palmer index around 0; but 20 inches would be less than half the yearly average in Virginia, and would probably correspond to an index lower than -5.0, signifying an exceptional drought in the state.

At the turn of the 19th century, the Great Plains were the last frontier of agriculture in the U.S. and witness to a trifecta of destruction: **The Dust Bowl.**

First, Congress passed generous federal farm policies, drawing thousands of pioneers west. They claimed vast swaths of semi-arid grasslands of the prairie; a dry, delicate ecosystem that relies on the deep roots of thick native grasses to hold the soil profile in place.

Second, the birth of mechanized farming led to the Great Plow-up, resulting in 5.2 million acres of thick, native grasslands being plowed up and converted to wheat fields.[xvi] Plow-based farming on semi-arid grasslands quickly led to the loss of fertile topsoil, leaving behind fields inhospitable to growing crops and vulnerable to drought.

Finally, World War I was driving wheat prices sky high, incentivizing more aggressive and destructive farming practices. The new Plains farmers moved in and tilled the land, upsetting the delicate balance of the grasslands, leaving an unstable land and the systematic destruction of the prairie grasses.

As the nation sank into the **Great Depression**, wheat prices plummeted from $2/bushel to 40 cents. In hopes of harvesting bumper crops, prairie farmers tore up even more prairie sod, which in turn flooded the market with surplus wheat that people were too poor to buy.

Adding insult to injury, in 1930 the **drought** set in. Across a 150,000 square mile area from Kansas to New Mexico, the rain stopped and the wind started. Without the strong root system of grass to anchor, the winds easily picked up the loose topsoil and swirled it into billowing clouds of dust or "black blizzards" that drifted like snow, blanketing over houses and barns and choking livestock and people.

With nothing but sand where there once was farmland – *and grasslands before that* – farmers fled for work in California and elsewhere. At its peak, the Dust Bowl drought affected the entire Plains region, 35 million acres of farmland and more than **60 percent of the country**. By 1940, more than 2.5 million people had been swept away by the Dust Bowl along with 850 million tons of topsoil.

THE DUST BOWL

FLOOD 101

Flooding is also a natural occurrence, and a necessary, beneficial part of ecosystems such as floodplains, wetlands and marshes. As flood waters recede, they leave behind nutrient rich silt deposits, contributing to rich, fertile soil. Rich **floodplain soil** makes up the farmland of the Mississippi Valley – America's largest floodplain – that supports the agriculture that feeds the U.S. and the world.

According to the National Oceanic and Atmospheric Administration (NOAA), a flood is:

> *An overflow of water onto normally dry land. The inundation of a normally dry area caused by rising water in an existing waterway, such as a river, stream, or drainage ditch. Ponding of water at or near the point where the rain fell. Flooding is a longer term event than flash flooding; it may last days or weeks.*

By their very nature, floodplains are near water, either river valleys or coastlines. As such, they are also typically **desirable real estate** and densely populated. To make matters worse, developers fill and build on wetlands that are designed to act as natural flood buffers and sponges.

But floods can happen **anywhere** it rains. Flood risk is based on several factors including topography, rainfall, flood control measures, river flow, tidal surge, and increases in impervious surface area due to development. In the past five years, all 50 states have experienced either floods or flash floods.

Floods are classified according to their likelihood of occurring in a given time period, such as the hundred year flood. The longer the time period, the more extreme the event. For example, a **hundred year flood** will be an extremely large, destructive event theoretically expected to only happen once every century. Another way to understand it is as a one percent chance that a flood of that magnitude would happen in any given year. With climate change, hundred year floods have been happening more frequently across the globe.

A dangerous ensemble of extreme weather events and hydrologic conditions set the stage for the Great Flood of 1993. An unusually wet fall in the year prior resulted in overflowing reservoirs in the Missouri and Upper Mississippi River basins and higher than normal soil moisture. In the spring and summer of 1993, persistent and repetitive storms bombarded the Upper Midwest with inordinate rainfall – more than **four feet of rain** in some areas.

By April, the Mississippi River was cresting **6 to 10 feet above flood** stage. After a brief reprieve in June, precipitation picked up again and the levees were overtopped and breached. July rainfall amounts of 5 to 7 inches within 24 hours were not uncommon, sending record setting crests down the Mississippi and Missouri Rivers, meeting at their confluence near St. Louis.

On the first day of August, 1993, the Mississippi River crested at nearly 50 feet – 20 feet above flood stage with a peak flow rate of more than one million cubic feet per second. On the same day, the levees broke down in Columbia, Illinois, **flooding 47,000 acres**.

Nearly all the privately built agricultural levees were breached or destroyed on the Missouri River. Locations along the Missouri remained under flood conditions for nearly 100 days and along the Mississippi for nearly 200 days.[xvii]

The National Oceanic and Atmospheric Administration (NOAA) reported more than **20 million acres were flooded** across nine states, destroying 50,000 homes and displacing 54,000 people. With the record river levels, the amount of property and crop damage, and the number of people displaced, the Great Flood of 1993 is considered the most devastating and costly flood in the modern history of the U.S.

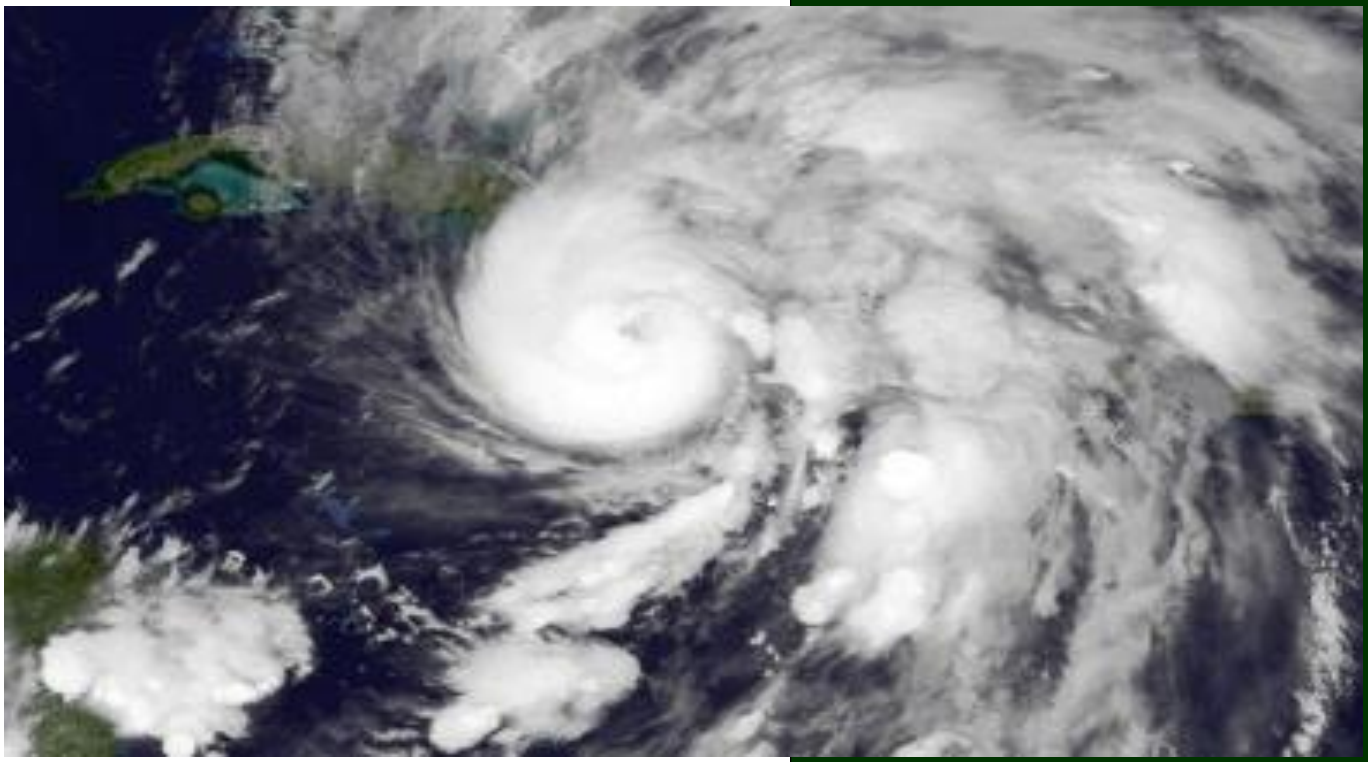
THE GREAT FLOOD OF 1993

CLIMATE CHANGE AND INTENSIFICATION

Climate change is bringing more extreme weather, creating more frequent, severe and widespread drought and floods.

These changes – referred to as **intensification** – will be the most noticeable impact for most of us in our everyday lives. As the earth warms, models show droughts will increase in subtropical areas such as the southwestern states and shifting weather patterns will push storms farther north, increasing chances of flooding.

- The amount of water vapor that air can hold is a direct function of its temperature.
- That amount grows exponentially as air becomes warmer
- For a 1 degree Celsius increase in the global mean surface air temperature (currently about 15 degrees Celsius) the capacity of the air to hold water vapor increases 7 percent
- The more moisture in the air, the more moisture can condense and fall as rain or snow
- This causes the atmosphere to be more thermally unstable, and more conducive to triggering thunderstorms and convective precipitation. Factors such as these appear to be behind the tendency toward more floods.



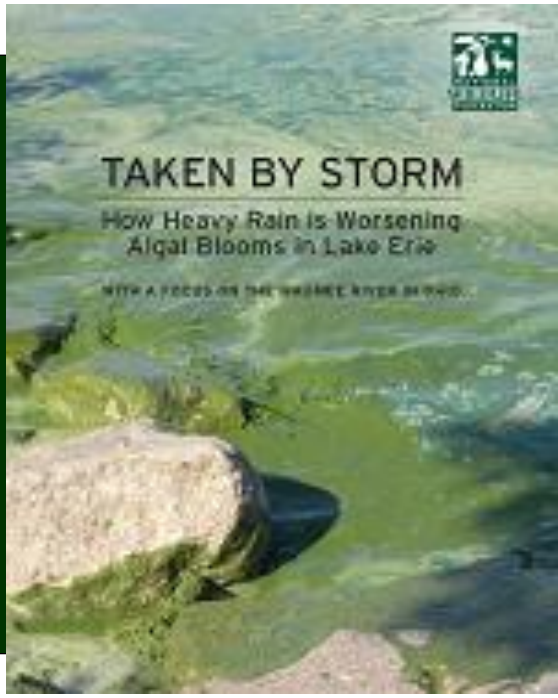
Over the past century, the planet's temperature has **increased by 1.4 degrees F** and scientists now project that it will continue rising another 2 to 12 degrees by the end of the century. Even these minor increases in average temperature can lead to major changes in climate and our weather system.[1]

Many regions are now experiencing **more** extreme climate events such as severe, intense rain and floods as well as **frequent**, severe heat waves and droughts. In the Midwest and Northeast, big storms that historically would only be seen once every 20 years are projected to happen as much as every 4 to 6 years by the end of the 21st century. At the same time, shifts in snowfall patterns, the onset of spring, and river-ice melting may all exacerbate flooding risks.[xviii]

Storms also develop much **faster** than in the past. Hurricanes and other tropical cyclones in the North Atlantic mature from a Category 1 to Category 3 a full day faster than 25 years ago. When storms intensify faster, they are stronger and more destructive when they make landfall. [xix] While the total number of storms has remained constant, the proportion of high-intensity events has gone up across the world. The amount of rain will remain constant, but rainfall is becoming increasingly concentrated into less frequent but more intense events.

Since the late 1990s, harmful algal blooms (HABs) have returned to the lake in force. Microcystis algae, which produce the toxin microcystin, have captured the attention of scientists, public health officials, and environmental advocates alike. There is widespread agreement that HABs are one of the most significant problems facing the people and wildlife of Lake Erie today.

Record-breaking rains—and droughts—are affecting the size of these toxic blooms. Why? Rain causes runoff of nonpoint source pollutants such as excess fertilizer and livestock waste, which cause an upsurge in lake nutrient levels and promote the growth of harmful algal blooms. Unfortunately, the changing global climate is bringing both extreme rainfall and significant drought to the Great Lakes region. These pendulum swings, which cause many industries to suffer, are contributing to record-breaking harmful algal blooms.



2011 FLOODING

In April 2011, high sea surface temperatures contributed to extra moisture and energy in the atmosphere, leading to massive thunderstorms and heavy rains across eastern Oklahoma and northwest Arkansas. More than **17 inches of rain** fell in an area where a typical April rainfall would be less than 5 inches. Prior to this event, the region had been in drought conditions, causing the ground to be compacted and impervious. The high quantity of rain in a short amount of time on compacted ground led to widespread flash flooding.

HURRICANE SANDY

Hurricane Sandy drove a massive storm surge onto the New Jersey and New York coastlines during fall of 2012, destroying entire communities and **claiming at least 147 lives**, making Sandy the deadliest tropical cyclone since Hurricane Agnes in 1972. With at least $50 billion in damage, she was also the second most expensive cyclone to hit the U.S. since 1900.

THE COSTS OF DROUGHT AND FLOOD

Extreme weather events are more than dangerous and destructive, they are often devastatingly expensive. According to the National Oceanic and Atmospheric Administration (NOAA), the 16 drought events between 1980 and 2012 cost America $210 billion.[xx] An independent insurance company estimated the cost of the 2012 drought to be more than $35 billion with the agriculture sector accounting for most of the losses.

Even with extensive mitigation and advanced prediction abilities, floods cause approximately $6 billion in damages every year.[xxi] And no sector gets hit harder financially from drought and flood than agriculture.

Because these extreme weather events rarely have a precise beginning or ending and generally cover an expansive – *but not always contiguous* – area, experts are challenged to make accurate impact assessments. However, understanding the economic as well as ecological damage of extreme weather events is essential for developing the policies and best practices to prepare for, recover from and mitigate the impacts. Accurate loss estimates can not only facilitate relief efforts, they are needed for investment decisions for mitigation activities.

AGRICULTURE AND CO$T

With the first signs of **drought**, farmers begin to feel the heat. To compensate for lack of rainfall, farmers may need to spend additional funds on irrigation or drilling new wells. Prolonged soil moisture deficits cause crops to dry out and fail. Pastures yellow and wither, providing inadequate feed for livestock, causing ranchers to spend additional funds to purchase feed and water for their herds. The long term impacts of on perennial crops and livestock production can linger for several years.

According to USDA's Economic Research Service, the 2012 drought had an adverse effect on more than two-thirds of the continental United States and carried an estimated cost of $30 billion to the agricultural sector alone. National per-acre corn production dropped 26.3 percent and soybean production dropped 8.1 percent.

Floods leave behind big costs for communities and taxpayers. Between 1980 and 2013, the United States suffered more than $260 billion in flood-related damages. Recent examples include record flooding from excessive rainfall in central and northern Illinois in April 2013 that damaged homes and businesses and caused an estimated $1 billion in losses.

Floods also claim crops and pastures, but they have additional costs not seen in drought such as damage to or total loss of equipment, buildings and displacement of people and livestock. Often, rural areas are sacrificed; farmland purposely flooded when levees are opened to protect nearby heavily populated metropolitan areas. During the 2011 Mississippi River flood, officials opened the Morganza Spillway, flooding farmland and homes in order to save the city of New Orleans.[xxii]

Even for those farmers spared the immediate effects, the destruction of **transportation infrastructure** makes moving products to and from markets nearly impossible. On the Mississippi river, the barges transporting billions of dollars' worth of crops are delayed.

Drought and flood induced losses are not borne by farmers alone. Production losses cause negative supply shocks and a portion of the losses are passed on to consumers through increased food prices. Businesses that rely on farming such as companies that sell equipment and supplies may lose business during a drought induced downturn. More domino effects occur when crop losses lead to supply reductions for downstream industries such as food processors and ethanol plants, causing them to have to bid higher prices for their inputs or reduce their production. Consumers suffering from income and asset losses due to the disaster are even less able to pay higher prices, reducing their expenditures, creating another ripple of economic impacts.

At the **municipal** level, the social costs of floods are also considerable, with every aspect of public service affected if not destroyed. Public buildings, parks and lighting as well as roads and bridges need immediate repair. Waste water, fresh water, and hazardous waste facilities are often compromised.

Degraded soil is more likely to **erode**, contributing further to the financial burdens associated with flooding. States and municipalities spend billions removing eroded sediment from ditches, culverts, ports, barge traffic channels and even drinking water.[xxiii]

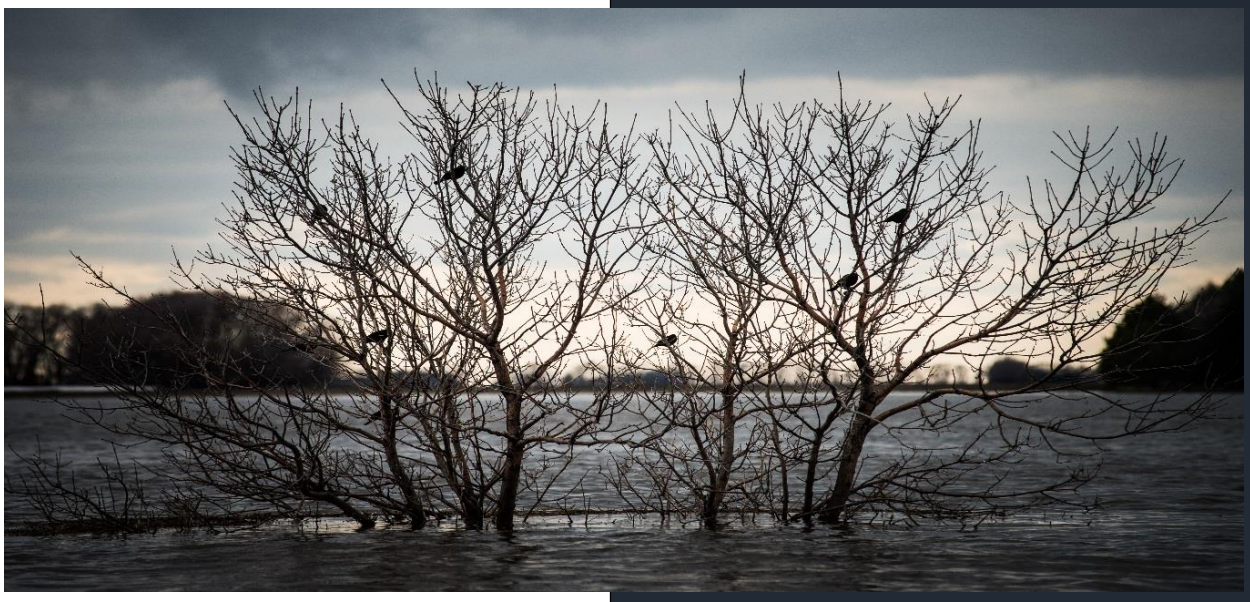
COST OF INSURANCE

CROP INSURANCE

Most people are familiar with typical insurance policies, such as auto, property and health insurance. Customers pay a premium to private insurance companies to indemnify their possible losses, and to cover processing, overhead and profit for the companies to operate as a business. However, with crop insurance, farmers pay only 40 percent of the premium, while taxpayers cover the other **60 percent**, along with the additional costs for processing agency commissions and insurance company profits. In years when payments exceed premiums – such as the drought of 2012 – taxpayers also cover a large share of the losses.

A February 2015 GAO report found that the federal government's crop insurance costs are **substantially higher** in areas with higher crop production risks (e.g., drought risk) than in other areas. In the higher risk areas, government costs per dollar of crop value for 2005 through 2013 were over two and a half times the costs in other areas.

For the 2012 drought, nearly 282 million acres were enrolled in the Federal crop insurance program, including 90 percent of cotton, 85 percent of corn, wheat and soybean acres and 80 percent of rice. In 2013, insured farmers – mostly in the Midwest – received **$14.2 billion** in indemnity payments, including $9.3 billion for corn and $2 billion for soybean. Many farmers are also eligible to receive direct disaster relief from the government during the most severe events.



FLOOD INSURANCE

America has a long history of being short sighted about floods. Until 1968, we relied on some prevention via flood control measures such as dams, levees, seawalls and provided ad hoc **disaster relief** after the damage was done. Unfortunately, we didn't have the foresight to discourage dangerous development in flood prone areas, and in many places, even encouraged it.

Due to the astronomically high costs, insurance companies were unable to provide affordable flood insurance. Because traditional homeowner insurance policies don't cover floods, and disaster relief became too much of a burden on taxpayers, Congress created the National Flood Insurance Program in 1968. Today, **5.5 million property owners** hold federal flood insurance policies, 80 percent of whom pay market rates. Every property with a mortgage in a designated flood plain must have flood insurance, and the federal government insures a vast majority of them.

Overseen by the Federal Emergency Management Agency (FEMA) the program is based upon agreements between local communities and the federal government. Communities must adopt and enforce a **floodplain management ordinance** to reduce future flood risks in Special Flood Hazard Areas (SFHAs) and in return, the federal government makes flood insurance available in that designated area.

Homeowners, business owners and renters can purchase federally backed flood insurance, with average annual premiums at approximately $650 and can cover both buildings and personal property.

Even with sophisticated flood mitigation and advanced prediction capabilities, underwriting flood insurance hasn't been cheap for American taxpayers.

- From 2008 to 2012, the average flood claim was approximately $42,000
- Between 2003 and 2012, flood insurance claims averaged nearly $4 billion per year.
- In 2012, the NFIP paid $7.7 billion in flood insurance claims.[xxiv]
- By 2011, the NFIP was $18 billion in debt following Hurricanes Katrina, Gustave and Ike, increasing the national debt and deficit.[xxv]

BY THE NUMBER$

COST OF DROUGHT

From 2011 to 2013, the Federal Crop Insurance Corporation (FCIC) lost **$40 billion**.[xxvi]
From 1980 to 2012, 16 drought events cost America **$210 billion**.[xxvii] (NOAA)
Using USDA Economic Research Service estimates, the 2012 drought increased grocery expenses for US consumers by 1.8 percent, or **$24 billion** in 2013. As the country's single largest purchaser of food, the increase cost the US government **$2.3 billion**.[xxviii]

COST OF FLOOD

From 2008 to 2012, the average flood claim was approximately **$42,000**.
Between 2003 and 2012, flood insurance claims averaged nearly **$4 billion** per year.[xxix]
The National Flood Insurance Program was **$23 billion** in debt as of 2014.[xxx]
30 Year Flood Loss Averages = **$7.96 Billion** in damages/year, 82 fatalities/year[xxxi]

COST OF COVER CROPS

Median cost of seed = $25 per acre.
Median cost of seeding/custom planting/establishment = $12 per acre.
Total cost = **$37 per acre**.

At the 2014 Cover Crops and Soil Health conference, soil health scientists, agriculture professionals and policymakers discussed a national goal of **20 million acres** under cover crops by 2020.[xxxii]

At $37 per acre, the total cost of meeting that goal immediately would be **$740 million**.

THE POLICY OF DROUGHT AND FLOOD

In the United States, we have hundreds of organizations – public and private – working on providing the best planning and response for extreme weather events like drought and flood. Congress passes laws and appropriates monies for research, regulation and relief funding. Government scientists are improving prediction tools to map and model pending events while engineers are improving infrastructure to prepare and protect communities.

Government, by nature is reluctant to commit resources and funding to projects without adequate information on the costs versus the benefits. The success of drought and flood mitigation by nature is uncertain and difficult to predict. Our current policy for extreme weather events can be characterized as largely reactive; short term responsive action rather than long term proactive planning and mitigation.

While we cannot prevent drought or flood, we can do a better job of preparing for extreme weather events and mitigating the damage after. And while continuing early warning systems and disaster relief programs is essential, there are other measures to increase preparedness and improve risk management for farmers. Measures that are less expensive, more successful and have multiple ancillary benefits – and one of the best risk management tools available is the increased adoption of cover crops.

GOVERNING BODIES IN CHARGE OF DROUGHT AND FLOOD POLICY	
White House **National Drought Resilience Partnership** **President's State, Local and Tribal Task Force on Climate Preparedness and Resilience**	As part of President Obama's Climate Action Plan, the Administration launched the National Drought Resilience Partnership to make it easier for communities to access the drought assistance they need by promoting strong partnership and information sharing at all levels of government. Participating agencies include the National Oceanic and Atmospheric Association (NOAA), the United States Department of Agriculture (USDA), the Department of the Interior (DOI), Assistant Secretary for the Army Civil Works (ASA-CW), the Federal Emergency Management Agency (FEMA), the Environmental Protection Agency (EPA), and the Department of Energy (DOE). In January, 2015, President Obama signed an executive order establishing the Federal Flood Risk Management Standard that will reduce the risk and cost of future flood disasters by requiring all federal investments in and affecting floodplains to meet higher flood risk standards.
National Oceanic and Atmospheric Administration (NOAA) **National Weather Service**	NOAA provides weather, water and climate data, forecasts and warnings for the protection of life and property and enhancement of the national economy. Climate Prediction Center – Drought Monitoring The National Integrated Drought Information System (NIDIS) Flood Safety Center
U.S. Department of Agriculture (USDA)	USDA works with producers, communities, affected states and other agencies to address impacts of drought and flood. The Watershed and Flood Prevention Operations (WFPO) Program provides technical and financial assistance to states, local governments and tribes to plan and implement authorized watershed project plans for the purpose of: • watershed protection • flood mitigation • water quality improvements • soil erosion reduction • rural, municipal and industrial water supply • irrigation • water management • sediment control • fish and wildlife enhancement • hydropower USDA's Climate Change Adaptation Plan presents strategies and actions to address the effects of climate change on key mission areas including agricultural production, food security, rural development, and forestry and natural resources conservation. USDA's Climate Hubs develop and deliver science-based, region-specific information and technologies to agricultural and natural resource managers for climate-informed decision making and assist with implementation.

U.S. Army Corps of Engineers (USACE) **USACE Flood Risk Management Program (FRMP)**	The USACE Flood Risk Management Program (FRMP) works across the agency to focus the policies, programs and expertise of USACE toward reducing overall flood risk. This includes the appropriate use and resiliency of structures such as levees and floodwalls, as well as promoting alternatives when other approaches (e.g., land acquisition, flood proofing, etc.) reduce the risk of loss of life, reduce long-term economic damages to the public and private sector, and improve the natural environment.
National Drought Mitigation Center (NDMC), University of Nebraska-Lincoln	The National Drought Mitigation Center (NDMC) helps people and institutions develop and implement measures to reduce societal vulnerability to drought, stressing preparedness and risk management rather than crisis management.
Natural Hazards Center at the University of Colorado at Boulder	The mission of the Natural Hazards Center at the University of Colorado at Boulder is to advance and communicate knowledge on hazards mitigation and disaster preparedness, response, and recovery. Using an all-hazards and interdisciplinary framework, the Center fosters information sharing and integration of activities among researchers, practitioners, and policy makers from around the world; supports and conducts research; and provides educational opportunities for the next generation of hazards scholars and professionals.
U.S. Congress **House Natural Resources Committee** **Senate Energy and Natural Resources**	The House Subcommittee on Water, Power and Oceans is responsible for matters concerning America's water resources, federal irrigation projects, generation of electric power from federal water projects, interstate water issues and fisheries management. The Senate Subcommittee on Water and Power oversees irrigation; reclamation projects, including related flood control purposes; power marketing administrations, energy development impacts on water resources; groundwater resources and management; hydroelectric power; low head hydro; and energy related aspects of deep water ports.
Governors **National Governors Association**	In cases of drought and flood, governors can declare a state of emergency, divert funds for community relief, to lease water rights, boost stream flows, provide water for agriculture and fisheries and create alternative water supplies. The NGA Natural Resources Committee focuses on water supply, quality and conservation, public drinking water source protection, flood protection, flood plain management, land use and fish and wildlife resources protection.
State Floodplain Managers **The Association of State Floodplain Managers**	The mission of ASFPM is to promote education, policies, and activities that mitigate current and future losses, costs, and human suffering caused by flooding, and to protect the natural and beneficial functions of floodplains - all without causing adverse impacts.
National Association of Flood & Stormwater Management Agencies	The National Association of Flood & Stormwater Management Agencies (NAFSMA) is an organization of public agencies whose function is the protection of lives, property and economic activity from the adverse impacts of storm and flood waters. The mission of the Association is to advocate public policy, encourage technologies and conduct education programs which faciliate and enhance the achievement of the public service function of its members.
U.S. Government Accountability Office (GAO)	The U.S. Government Accountability Office (GAO) is an independent, nonpartisan agency that investigates how the federal government spends taxpayer dollars at the request of congressional committees.

RECOMMENDATIONS

Considering the increase in frequency and severity of extreme weather events, the immense costs of preparation and recovery, we encourage the extensive existing cadre of agencies, organizations and experts currently engaged in drought and flood policy to include cover crops as integral part of implementation going forward. Responsibility and leadership is needed from all levels, from the White House to individual producers:

1. Add cover crops to existing plans, strategies, legislation and regulation
2. Inform agriculture industry about benefits of cover crops
3. Incentivize the adoption of cover crops
4. Continue research (agronomic and economic) on benefits of cover crops

White House	Update President Obama's Climate Action Plan to include cover crops
National Drought Resilience Partnership	Promote cover crops to participating agencies and affected communities via the National Drought Resilience Partnership
President's State, Local and Tribal Task Force on Climate Preparedness and Resilience	Update the Federal Flood Risk Management Standard that requires all federal investments in floodplains to meet higher flood risk standards to include incentives and guidance on cover crop adoption
U.S. Department of Agriculture (USDA)	Include technical and financial assistance for cover crop adoption to states, local governments and tribes via the Watershed and Flood Prevention Operations (WFPO) Program Update the USDA Climate Change Adaptation Plan to include cover crops Include cover crops as a science-based agriculture tool for responding to impacts of a changing climate via the USDA Climate Hubs. Support cover crops research, provide outreach, education, technical assistance to natural and education resource managers.
NRCS	Create setasides for cover crops as drought/flood mitigation in funding programs such as EQIP, CSP, CIG and RCCP, where appropriate
SARE	Provide funding for pilot projects to demonstrate the drought/flood mitigation benefits of cover crops Provide cover crop outreach and education to various segments of the agriculture industry including producers, cooperatives, elevators, seed sales and other input suppliers

Economic Research Service **RMA**	Conduct a thorough cost-benefit analysis of current spending on mitigation impacts of drought and flood versus cost of widespread cover crop adoption (with GAO) Eliminate all barriers to cover crop adoption Educate RMA staff and crop insurance industry on cover crop benefits as risk management for drought and flood
National Drought Mitigation Center (NDMC), University of Nebraska-Lincoln	Because the NDMC stresses preparedness and risk management rather than crisis management, the Center should include promoting cover crops as a measure that reduces societal vulnerability to drought
Natural Hazards Center at the University of Colorado at Boulder	Because the NHC advances knowledge on hazards mitigation and disaster preparedness, response, and recovery, the Center should include cover crops in their research, information sharing and education of hazards scholars and professionals
U.S. Congress	In all reauthorizations related to extreme weather event preparedness, response and recovery as well as the Farm Bill, include research, funding, training, outreach and capacity building for the promotion of increased cover crop adoption as mitigation for the impacts of drought and flood.
Governors	Direct state agriculture agencies to promote the use of cover crops to mitigate and recover from the impacts of drought and flood
State Floodplain Managers, The Association of State Floodplain Managers	Include cover crop adoption in all aspects of the ASFPM's efforts to promote education, policies, and activities that mitigate current and future losses, costs, and human suffering caused by flooding
National Association of Flood & Stormwater Management Agencies	Include cover crops in NAFSMA's promotion of public policy, technologies and education to protect lives, property and economic activity from the adverse impacts of floods.
U.S. Government Accountability Office (GAO)	Conduct a thorough cost-benefit analysis of current spending on mitigation impacts of drought and flood versus cost of widespread cover crop adoption (with ERS)

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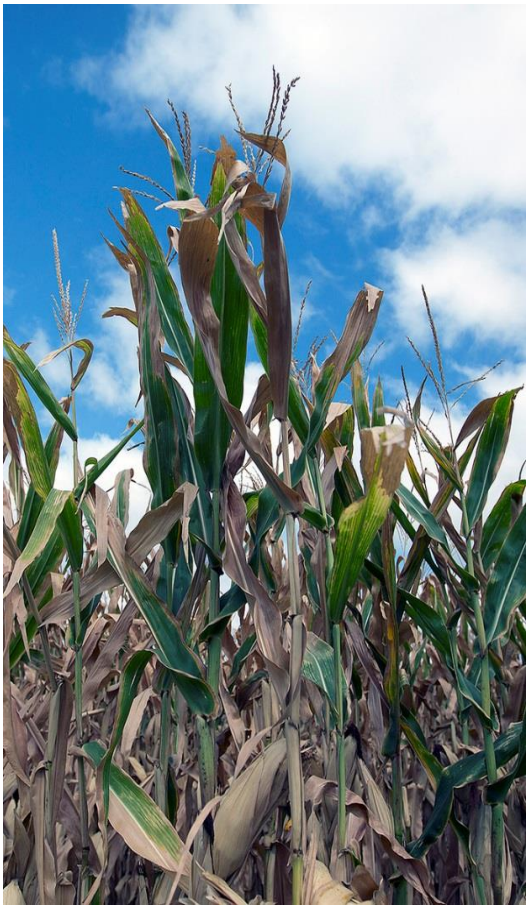

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