SOLUTIONS FROM THE LAND

Indiana Smart Agriculture:

Building a Resilient Future for Indiana Farms and Forests

2024

SOLUTIONS FROM THE LAND

Indiana Smart Agriculture Work Group

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FOREWORD

Over the past two-and-a-half years, the Indiana Smart Agriculture Work Group has been examining the status of and challenges facing the state's agricultural industry. This self-directed, farmer-led team, with support from Solutions from the Land and Purdue University's College of Agriculture, has made the impact that extreme weather and changing climatic conditions are having on the sector a key focus of this examination.

In our first phase of work, we reviewed the impacts that these events and conditions are having and are expected to have on the state's agriculture and forestry sectors. We also assessed the need for and benefits of developing an agricultural and forestry adaptive management strategy for the state based on climate smart agriculture (CSA) principles.

Following a series of meetings and consultations with producers, academic experts and value chain partners across the state, we concluded that:

- **The climate is changing**, and the resulting conditions are a **threat multiplier** for Indiana agriculture.
- Indiana and the ag industry as a sector would benefit from the development of a **farmer-led adaptation/mitigation strategy** for presentation to their peers, policy makers, researchers and value chain partners.
- **Producers need to lead** CSA conversations and adaptive management planning work.

Grounded by these findings, we then invited stakeholders from across the agriculture and forestry value chains in Indiana to join us in forming a diverse, multi-stakeholder, cross-boundary collaborative to construct and build support for a climate smart strategy and action plan which can guide future policies, programs, partnerships and investments needed for Indiana agriculture to adapt and thrive.

This report and its associated action recommendations are the result of this work. While we outline and propose solutions to the challenges that climate change is creating, we also highlight opportunities that Indiana agriculture, in all its dimensions, can capitalize on.

Our target audience for this report is as diverse as Indiana agriculture itself: farmers, livestock producers, foresters, policymakers, government officials and our many conservation, value chain and academic partners. Most importantly, this body of work is more than a report. It is a call to action to ensure that Indiana agriculture remains vibrant, innovative, resilient and productive for generations to come.

On behalf of the Indiana Smart Agriculture Work Group,

Don Villwock, *Co-Chair*
3rd Generation Farmer
Edwardsport, Indiana

Tom McKinney, *Co-Chair*
7th Generation Farmer
Kempton, Indiana

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Grassed waterway in Spencer, Indiana, corn field.

INDIANA AGRICULTURE: DIVERSE AND THRIVING

Indiana is making strides in conservation, training and management arenas that help lay the crucial groundwork for preparing the state's farmers, farmland and agricultural industries for the many challenges ahead.

From row crops to livestock production to its hardwood forests, Indiana has a robust and diverse agricultural industry and leads the nation in many sectors. More than 80% of its land is devoted to farms and forests.[1]

The volume and value of agricultural production has stayed strong and even grown by several key measures this year. Indiana is now the 8th largest state in terms of farm income and market value of the agricultural products produced.[2]

Perhaps even more importantly, Indiana is making strides in conservation, training and management arenas that help lay the crucial groundwork for preparing the state's farmers, farmland and agricultural industries for the many challenges ahead.

Notable examples of positive developments are:

- Records set by Indiana landowners in the last year for **planting 1.73 million acres of farmland to living cover** across all crops in the state[4] and for **increasing the number of new conservation practices installed** with support from the Indiana Conservation Partnership by 3,000, to a new record of more than 50,000.[5] In Indiana, the most common practices are cover crops, nutrient management, residue and tillage management, conservation cover, early successional habitat development/management and grassed waterways.
- The new **Purdue On The Farm** program, designed to connect Purdue University Extension more directly with its clientele and partners.
- The milestone of reaching **700,000 4R Nutrient Stewardship Certified acres** in Indiana in August 2024, increasing the farmland on which farmers and applicators use the best practices of the Right Source of Nutrients at the Right Rate and Right Time in the Right Place.[3]
- **The "Farming for a Better Climate" series** from Purdue, an online, science-based guide discussing ways for producers to maintain or increase profits while slowing climate change.[6]

Photo credit: NRCS/Brandon O'Connor

PURDUE ON THE FARM

Photo credit: Purdue University (both photos)

Fostering Connections Between Farmers and Purdue.

A lot of things changed in 2020 due to the COVID-19 pandemic, including the way Purdue Extension connects with farmers. Virtual meetings replaced in-person meetings, and, at a certain point, a group of Extension specialists at Purdue's main campus in West Lafayette realized they were not seeing or talking to farmers as much as they once did.

"We realized we needed more connections," recalls Joe Rorick, a Purdue agronomist who coordinates on-farm sustainability programs and research. "We realized there was a need. This was what people wanted: to reconnect, to get closer. Farmers were asking, 'How can Purdue help me?'"

Their answer was Purdue on the Farm, a four-tiered program designed to connect Purdue Extension with farmers and partners to build and enhance relationships and better understand

the current situation and needs of farmers across the state.

"Purdue on the Farm is all about relationships," says Scott Gabbard, Purdue on the Farm senior administrator. "It is a platform on which educators, researchers and farmers can work together to keep Indiana competitive for years and decades to come."

The four-tiered approach allows farmers to jump in and engage with Purdue at the level they desire. At the foundational 1) level is a questionnaire for farmers to share what practices they use and their opinions on different topics, which Rorick says helps university faculty "keep their finger on the pulse of what's going on."

For example, Purdue is interested in monitoring new diseases in soybean, like red crown rot, that are popping up across the state, in part because environmental changes. The survey also informs research and outreach efforts so Purdue can better target its work to benefit farmers.

Some farmers will want to participate in the next tier levels: 2) early-season, mid-season and late-season crop scouting; 3) demonstration, such as on-farm field testing of products, hybrids, and practices with the support of Extension agents and specialists, and 4) on-farm research, a deeper level of study aiming to develop protocols and answer questions on seeding rates, fertilizer use, etc., with Extension and farmer input.

Rorick's favorite part of working with Purdue on the Farm is seeing people get excited about it. In 2024, the group worked with the Indiana Soybean Alliance and Indiana Corn Marketing Council to get field signs so that farmers driving by can see where Purdue is doing work. It created a lot of buzz in the ag community.

"People are calling in, wanting to know how they can get more information, how they can find out about what's going on," Rorick says.

Learn more online about Purdue on the Farm or contact the program at potf@purdue.edu.

- **The Diversified Farming and Food Systems Team of Purdue Extension,** which works to connect programming, research and learning focused on urban agriculture, community wellness, local food, beginning farmers, small farms and organic agriculture.[7]
- **The new Farm Advisors mentorship program** that aims to connect Indiana farmers for knowledge-sharing about climate smart practices, like no-till and cover-cropping. (See p. 8)
- **The Diverse Corn Belt project,** a five-year, $10 million multi-disciplinary project that explores the real-world impacts of diversified farming systems. Purdue horticulture and landscape architecture professor Linda Prokopy leads a team of researchers from Indiana, Illinois, Iowa and other states in a mission to understand the agronomic, economic, social, and infrastructure and policy changes that could make diversification in the Corn Belt viable.[8]

These examples are but the latest evidence of the strong partnerships that thrive in Indiana among commodity groups, agribusiness associations, farm cooperatives and the many state and federal entities that support agricultural endeavors. One such partnership is the Indiana Conservation Partnership, composed of eight Indiana agencies and organizations who share a common goal of promoting conservation.[9]

The INSA Work Group encourages even more alignment and integration among the many stakeholders setting and implementing Indiana's agriculture, clean energy and natural resource goals. Even with Indiana's strong history and encouraging recent developments, the group believes there is much more to be done to

sustainably intensify production levels and improve resilience while at the same time delivering climate mitigation and other ecosystem services.

A Leading State in Ag and Forestry Production

Indiana has long been a leader in agricultural production, currently No. 6 in the nation in value of the crops produced by approximately 53,300 farms on 14.6 million acres of farmland, and ranking high in several categories (Figure 1).

The state is fortunate to have highly productive and valuable land, being one of the four states with the highest average farm real estate values between the coasts, at $8,700 per acre in 2024 per USDA-NASS.[10] Indiana farmland prices continued to hit record highs in 2024, according to the latest Purdue Farmland Value and Cash Rents Survey results. The average price of top-quality farmland reached $14,392 per acre, a 4.8% increase from June 2023.[11]

Agriculture's Contribution to Indiana

Just as Indiana stands out as a top-ranking agricultural state, agriculture is a pillar of the state's economy, contributing an estimated $35.1 billion annually. More than 80% of Indiana's land is devoted to farms and forests. Every 10 jobs directly related to agriculture support an additional eight jobs in the state.[1]

The value of unprocessed Indiana agricultural commodities alone reached more than $18 billion a year according to 2022 USDA census data, growing 62% over five years.[1] The state's agricultural exports total $7.4 billion a year.[1] Long a leader in major grain crops, Indiana is also a

INDIANA AG: PRODUCTIVE AND GROWING

- **8TH largest farming state in U.S. in farm income (ag cash receipts, gross receipts, net & gross farm income)**
- **No. 1 in ducks, popcorn & gourds**
- **No. 2 in pumpkins**
- **No. 3 in turkeys, spearmint & cropland planted with a cover crop**
- **No. 4 in soybeans & peppermint**
- **No. 5 in corn & hogs**
- **No. 7 in value of total ag exports ($7.4 billion in 2022)**
- **No. 6 in value of all crop production, shell/contracted eggs & watermelons**
- **No. 10 in maple syrup & hemp for floral (CBD & other cannabinoid usage)**

Figure 1. Indiana agriculture stands out in several state production rankings.[1]

Photo credit: NRCS/Brandon O'Connor

national leader in producing ethanol and biodiesel from crops grown here. The specialty crop industry is strong, with vegetable production valued at $223.6 million annually and fruit and tree nuts bringing in another $25.3 million.[10]

Indiana's livestock industry is a national leader in duck, turkey and egg production,[1] contributing to the state's economy while providing an important local market for feed crops grown here. Pork is Indiana's fifth largest agricultural export.[12]

A notable segment of Indiana's agriculture has long been its forests, offering a sustainable and natural raw material for manufacturers. The state's hardwood industry supports 70,000 jobs. As a major renewable and environmentally valuable resource, Hoosier forests are growing in volume on average at a rate more than 1.8 times the amount of timber being removed and used.[1]

Indiana's Farms and Farmers

Indiana prides itself on the hard-working, industrious, collaborative and resourceful character of its farmers and farming communities that are the backbone of Indiana agriculture. The latest census counts just over 94,000 farmers in the state on 53,600 farming operations of an average size of 272 acres. Ninety-four percent of farms are family-owned or -operated.

The average age of Hoosier farmers is 56. Young producers under 35 years old total just over 11,000 in number. Farmers reporting as new and beginning (fewer than 10 years' experience) total 26,428, average age 43. Potential future farmers and agribusiness people span the state, with FFA chapters in 90 of Indiana's 92 counties.[1]

FORESTRY IN INDIANA

Well-managed Forests Help Economy and Environment.

Hardwoods, which include wood from trees like oak and hickory, contribute more than $10 billion to Indiana's economy each year. They grow on Indiana's 4.9 million acres of forest land, more than 80% of which are managed privately.

Trees provide an important windbreak for crop production on many Indiana farms, and they help keep the air and water clean while providing wildlife habitat, all ecosystem services that benefit everyone in the community. Forestry also can offer farmers an additional source of income.

"In forestry, we call ourselves the 'patient farmers,' because our crop doesn't produce every year, maybe every 20 to 40 years," says Ray Moistner, Indiana Hardwood Lumbermen's Association executive director. "It can be valuable in family planning and financing big expenses."

Challenges to Indiana Forests

The challenges facing forestry in Indiana are some of the same facing agriculture more broadly. Foresters represent a specialized workforce that is aging. It's also difficult to find workers on the logging and manufacturing side.

"Loggers risk their lives out there every day, so definitely it's a specialized type of work," Moistner says. "It's also very expensive to get into because of the equipment. It's hard to get a young person started in logging unless he comes from a family logging business."

There's also pressure from environmental stakeholders and policymakers who do not understand the importance of managing forests, which includes responsible logging practices that keep the forest environment healthy and provide consumers with everyday products made with natural materials. Not managing the forest well results in overgrowth that disrupts the ecosystem balance and becomes fuel that feeds wildfires.

"We need people managing the forest to make sure there's always openings where sunlight can get through and species like oak and hickory can regenerate and not get shaded out by maples and beeches that would otherwise dominate the forest landscape," Moistner says.

"We've got to take care of our forests. We have to take advantage of this environmentally friendly, renewable resource for our own futures."

INDIANA: A LUMBER LEADER[13]

National rankings:

No. 1 in producing wood office furniture and hardwood veneer

No. 2 in wood kitchen cabinets, countertops, and manufactured homes

No. 3 in engineered wood products

No. 4 in pre-fabricated wood buildings

No. 5 in upholstered household furniture.

THE POWER OF A MENTOR

New "Farm Advisors" Program Connects Indiana Farmers as They Adopt Climate Smart Practices.

Jim Moseley, a former U.S. deputy secretary of agriculture, knows the value of a mentor when it comes to farming.

He has no-tilled his land in Tippecanoe County, Indiana, for more than 35 years and also cover-cropped the last 10. He recalls the first four years of no-till as a challenging time of rebuilding so that the soil would become biologically active again. But today, his soil carbon levels are higher than they were in the 1960s, resulting in more-resilient soil in years with less-than-ideal weather.

Moseley saw proof of that in the dryness of 2023, when the timely July rain that stimulated his corn to pollinate was followed by little to no rain the whole next month. To his surprise, his yields were still well above his farm's historical averages. The message his mentors had imparted over the years became a promise fulfilled: "The real benefit of the regenerative program is the reduction of yield loss in the stress years."

He credits much of his farming success to those mentors who were willing to share what they had learned either in their own farming experiences or in the soil laboratory.

"There have been so many people who have helped," Moseley says. "The more I learned, the more I realized it was complex. I realized you cannot do it without somebody holding your hand. It just doesn't work."

Jim Moseley

This is why Moseley recently helped found Farm Advisors, a mentorship program that aims to connect Indiana farmers with other farmers with more experience implementing climate smart practices, like no-till and cover-cropping. At the program's August 2024 launch, more than 30 Indiana farmers signed up to serve as mentors. He hopes the program will become a model for other Midwest states.

Farmers can sign up to be mentored or to mentor at **https://farmadvisors.ag.** Farm Advisors currently operates with administrative assistance from the **Conservation Cropping Systems Initiative,** a program of the **Indiana Conservation Partnership.** CCSI is a farmer-focused, farmer-driven program that works with local level partnerships and others to promote the adoption of practices and cropping systems that can lead to improved soil health.

The Key to Mentorship

As a mentor now himself, Moseley says he takes a "soft" approach, using his farm as a demonstration farm that farmers in his area watch to see what he will do next and how it will turn out. He continues to experiment, such as trying mechanical rolling this year as a method of terminating his mixed-species cover crop before planting corn.

Moseley wants to see more people adopt practices that build soil carbon and improve water quality across more acres in the Mississippi River basin. But he says it's essential that farmers ask their own questions and come to their own conclusions about what to try when on their farm.

"Hitting them over the head with a two-by-four and trying to force them into it doesn't work," he says. "You've got to get down to the point where they ask the question, 'Why is this important?' Once they can answer that for themselves, they're ready."

While there are webinars and YouTube videos farmers can watch to learn new practices, but he highly recommends they interact with other farmers in person. He says the farmer who tries to implement a new practice but fails – a common occurrence if they go it alone – is the hardest person to get back on the regenerative journey.

"That's where the mentor comes in," he says. "The mentor is there just as much to prevent failures as to extend the success they've had. Have a good mentor, and you can do this."

Photo credit: Jim Moseley

CHALLENGES AND OPPORTUNITIES: PRESENT AND FUTURE

Indiana producers tell us they face any number of challenges in their operation – labor shortages; the fragmentation and conversion of farmland to non-ag uses, which adds to issues with access to/cost of land; fluctuating market demand and prices; competition for and management of water; various environmental impacts of and on their operations; and, as we'll discuss first, indisputable evidence of a changing climate.
The INSA Work Group also heard the resilience among producers who believe that they can adapt and rise to overcome many of these challenges, first and foremost if they can remain profitable as they make the necessary changes and adaptations. There is no doubt of the need for collaboration and coordination throughout the value chain and among all stakeholders to find and enact the best possible solutions, together.

The Challenge of a Changing Climate

In late September 2024, the powerful remnants of Hurricane Helene inundated southern and central Indiana with damaging winds, heavy rains and flooding that hurt crops and slowed harvest. According to multiple climate attribution studies, climate change contributed significantly to Helene's extreme rainfall and was a factor in the rapid intensification of both Helene and Hurricane Milton that followed in early October.[14, 15]

These extreme weather events are the most recent examples of the sobering truth that changing climatic conditions are already happening and are a threat multiplier for Indiana agriculture, as the INSA Work Group concluded in our Phase One INSA Report: A Vision and Roadmap for Indiana Climate Smart Agriculture released in January 2023.[16] During 2022, the group studied multiple assessments of climate change observations and impact forecasts, including the 4th National Climate Assessment[17] and the 2018 Indiana Agriculture in a Changing Climate report,[18] and received detailed presentations by authors of those studies from the USDA Midwest Climate Hub and Purdue University.

These two climate reports and a new 2024 report[19] have documented the measurable changes specifically in Indiana's climate that are already occurring, and scientists are forecasting both what is to come and the potential impacts on Indiana agriculture, as well as the adaptation needed to increase resilience to and mitigation of climate change factors.

Summary of Key Conclusions

www.IndianaClimate.org

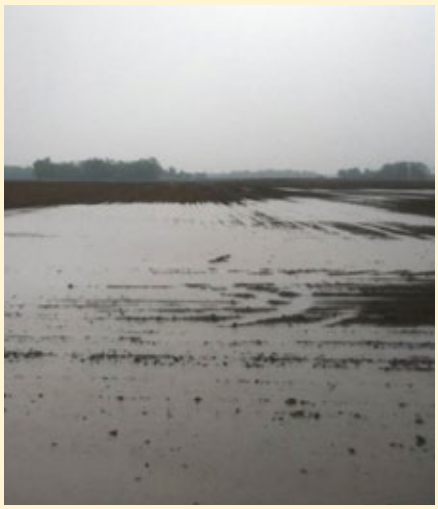
- **Increased heat (day and night) and water stress will reduce crop yields**
- **Warming winters put perenial crops at risk**
- **Heat stress and reduced forage quality will challenge livestock production**
- **Pests, disease and weeds will be a growing problem for Indiana agriculture**
- **Soil health and water quality at risk, especially from intense rain events**

There is potential for significant impacts, but also many opportunities to cope with changes and keep Indiana agriculture productive.

PURDUE UNIVERSITY College of Agriculture

IN CCIA Indiana Climate Change Impacts Assessment

Figure 2. From "Indiana's Agriculture in a Changing Climate" presentation prepared for the INSA Work Group, based on the Indiana Climate Change Impacts Assessment.



In central Indiana fields across the road from each other, this is what it looked like after 1.8 inches of rain. Field on left had been strip-tilled after growing corn and cover crops. Flooded field on right had three tillage passes after a soybean crop. Source: Conservation Cropping Systems Initiative

Documented Climate Changes and Their Impacts in Indiana

The most recent climate analysis shows that the average annual temperature in Indiana increased by 2°F between 1979 and 2021. While seasonal temperatures increased across all seasons, the most extreme rise was in the winter months. Average annual precipitation rose 7.3 inches – increasing most in winter and summer – with more-frequent extreme precipitation events.[19]

Those statistics are part of the August 2024 report, **Climate Change Impacts on Indiana Agriculture,**[19] whose authors also observe:

> "Like other regions in the United States, agricultural productivity in Indiana is vulnerable to weather and climate variability. Importantly, the impacts of climate change on the agricultural sectors extend beyond physical impacts to farms, but also bring direct and indirect impacts to overall cultural, social and economic resilience of Indiana's communities."

The latest report lists the following **observed impacts on agriculture and forestry in Indiana:**[19]

- Longer growing seasons and increased temperatures provide opportunities to plant alternative varieties of crops and trees.
- Shifting plant hardiness zones, due to increases in the average annual minimum temperatures.
- Increased crop water demand in recent decades, due largely in part to rising temperatures.
- There is some push-pull between increasing humidity (reduces water demand) and increasing temperatures (increases demand). Over the past 30-40 years, the trend has been toward increasing evaporative demand in the Great Lakes region.
- Greater frequency of heat stress (from heat and humidity) on trees, crops, livestock and farmworkers.
- Increased risk of damage from extreme events, including drought, severe storms and flooding.
- Increased weed, pest and disease pressure as well as animal pathogens.
- More erratic spring freeze/thaw cycles that may damage trees and fruit crops, as well as affect insect and pathogen survival.
- Late freeze events are still possible despite a trend towards earlier last spring freeze dates.
- Higher production costs and lower yields for some crops.
- Elevated overnight lows can increase corn respiration rates and shorten the grain filling period, both of which lead to a reduction in yield.
- Wetter soils, resulting in delayed agricultural planting, higher erosion and nutrient loss.

Future climate models show that "temperatures are projected to continue to warm, precipitation is expected to become more variable and extreme, and the growing season is anticipated to continue to lengthen."[19]

Climate scientists project two possible futures – "an intermediate scenario in which greenhouse gas emissions peak around mid-century and then slowly decline; and a very high scenario in which emissions continue to rise throughout the 21st century."[19]

Despite the challenges of present and future changes in Indiana's climates, the scientists and the INSA Work Group believe there are innate opportunities to be found – such as longer growing seasons and potential for storage and reuse of extra precipitation – as well as many ways to cope with changes and keep Indiana agriculture productive.

Photo credit: Conservation Cropping Systems Initiative

FARMING IN A NEW WORLD ORDER

In response to the conjoined triple threats of climate change; food and nutrition security; and loss of biodiversity, a new world order is emerging. Within countries and across the globe, governments and private industry alike are responding with a variety of goals, strategies, incentives, standards and requirements that will inevitably affect Indiana agricultural producers and industry. These developments can have both positive and negative implications for agriculture.

Climate and Emissions

As part of the Paris Agreement, the governments of participating countries are required to prepare and communicate Nationally Determined Contributions (NDCs) – the actions they will take reduce their greenhouse gas emissions to build resilience to adapt to the impacts of climate change. From the NDCs come environmental standards as well as adaptation and mitigation action plans that understandably will have an impact on agricultural practices.[20]

In the private sector, food companies, value chain partners and others in the supply chain are migrating quickly to account for emissions that are outside their direct control but that indirectly affect their value chain. These are known as Scope 3 emissions under the EPA's GHG (greenhouse gas) Protocol. As companies measure and work to reduce their Scope 3 emissions, there may be substantial opportunities in the form of incentives for farmers who use on-farm practices to reduce emissions.[19]

On the flip side, there are added pressures on farmers to invest in emissions mitigation with little to no reward, other than hoping to stay in business and retain market partners. As value chain partners step up and make commitments to both regulatory agencies and consumers, agricultural producers face an increasing number of standards and expectations for their production methods, transparency and product traceability.

Related to this is the role of farmers and foresters in the emerging low-carbon economy, with the potential for generating carbon credits through reducing emissions or sequestering carbon on their land. The shift to more renewable energy has already benefited farmers who lease their land for wind turbines or solar installations, sell their crops as feedstock for biofuels or even are

NEW CROP-COMPATIBLE SOLAR TECHNOLOGY

The experimental photovoltaic farm at Purdue University's Agronomy Center for Research and Education in fields of soybean and corn.

Purdue Innovation Advances Agrivoltaic Potential.

Purdue University researchers have improved upon traditional solar energy structures used in agrivoltaic farming, a sustainable system that generates electricity from the sun while row crops like corn, rice, soybeans and wheat concurrently grow on the same land.

The patent-pending Purdue structures and software are designed to optimize food production for farmers and maximize solar energy production.

The Purdue agrivoltaic structures use a dual, off-axis rotation system and sensors to optimize the amount of electricity generated and the amount of light that crops receive by rotating the panels to follow the sun and move the shadows they cast to enable more light to reach the growing crops. When farm equipment needs to pass, the modules will rotate to form a near-vertical structure. Research simulations show they can be mounted lower than traditional solar collection structures used in farm fields, reducing construction costs.

Photo credit: Purdue Agricultural Communications/Joshua Clark

cooperative owners of biofuel facilities.

It should be noted that in the case of solar, the positive opportunities to generate this renewable energy on farms via agrivoltaics co-exist with the competition for land and pressure on agricultural production posed by large-scale solar developments in the state.

On a positive note, the national collaborative Roads to Removal scientific report of 2023 lists cover crops and other conservation practices among effective options for carbon dioxide removal in the U.S.[22] Soil-based CO2 removal and storage is one of many benefits of cropland-management practices designed to reduce soil erosion, reduce nitrous oxide (N_2O) emissions, improve water retention, and provide bird and other wildlife habitat.[22]

The efforts of Indiana's livestock industry to mitigate climate change, especially methane emissions, may benefit from research at Purdue, such as work the Food Entrepreneurship and Manufacturing Institute[23] is doing to test the potential for using seaweed as a sustainable feed additive. The state also is a leader in use of agricultural digester systems treating manure and other wastes as they are converted into renewable natural gas and other valuable byproducts.[24]

The measurement of and potential economic rewards for the reduction of carbon intensity (CI) at multiple points along the food chain may be a game-changer for many Indiana producers. In particular, the Section 45Z Clean Fuel Production Credit, established by the Inflation Reduction Act (IRA) in the U.S., is a tax credit program designed to encourage the production of clean transportation fuels that may encourage and reward farmers for production practices that lower emissions and sequester more carbon.

While final details on the calculations and implementation of the 45Z tax credit for fuel producers are pending, it is expected that some farmers who implement specific climate smart agricultural practices may soon be eligible to receive a higher price for selling their corn or soybeans to ethanol and biodiesel plants.[24]

GASIFIER CONVERTS CORN STOVER TO ENERGY

Just on the horizon is an innovative on-farm energy system that can turn excess corn stover into beneficial byproducts such as electricity for use on the farm, biochar to sink carbon when used to improve soil tilth and hydrogen to sell. Called a gasifier, the system was developed by a team led by Peter Schubert, recently retired professor from Purdue University and Indiana University. The basic unit can be sustained with chopped corn stover from farms of 60 or more acres.

Opportunities While Meeting U.N. SDGs

Operating in a global economy means Indiana agricultural and forestry producers are subject to changing market demands for food and fiber as well as expectations to feed and clothe a growing world population in a sustainable fashion. It also can present opportunities that build upon the state's resources as producers and allied industries adapt and change.

Photo credit: Peter Schubert

The 2030 Agenda for Sustainable Development, approved by the UN General Assembly in 2015, put forth **17 Sustainable Development Goals** (SDGs) that target specific outcomes.[25] While agriculture factors into nearly all of the 17 goals, several of the goals are more directly associated with agricultural production, food systems, and agricultural livelihoods:

SDG1. No poverty (profitable livelihoods)

SDG2. Zero hunger (food production)

SDG3. Good health and well-being (nutrition)

SDG6. Clean water and sanitation (efficient management of water)

SDG7. Affordable clean energy

SDG8. Decent work and economic growth (promoting sustained, inclusive sustainable economic growth and full and productive employment)

SDG12. Responsible consumption and production (managing waste)

SDG13. Climate action (adapting to and mitigating climate change)

SDG14. Life below water; and

SDG15. Life on land (biodiversity dependent on sustainably managing farms and landscapes).

The strategies in Figure 3 are anchored by the three overlapping climate smart agriculture pillars: productivity, adaptation and resiliency, and greenhouse gas reduction. While such a CSA model does not prioritize any one of the pillars and represents the simultaneous co-benefits that accrue from their pursuit, the INSA Work Group's work and this report focus on systems and practices to help Indiana producers sustainably intensify production and improve resilience, leaving climate-change solutions (such as GHG reduction) as co-benefits of the first two pillars.

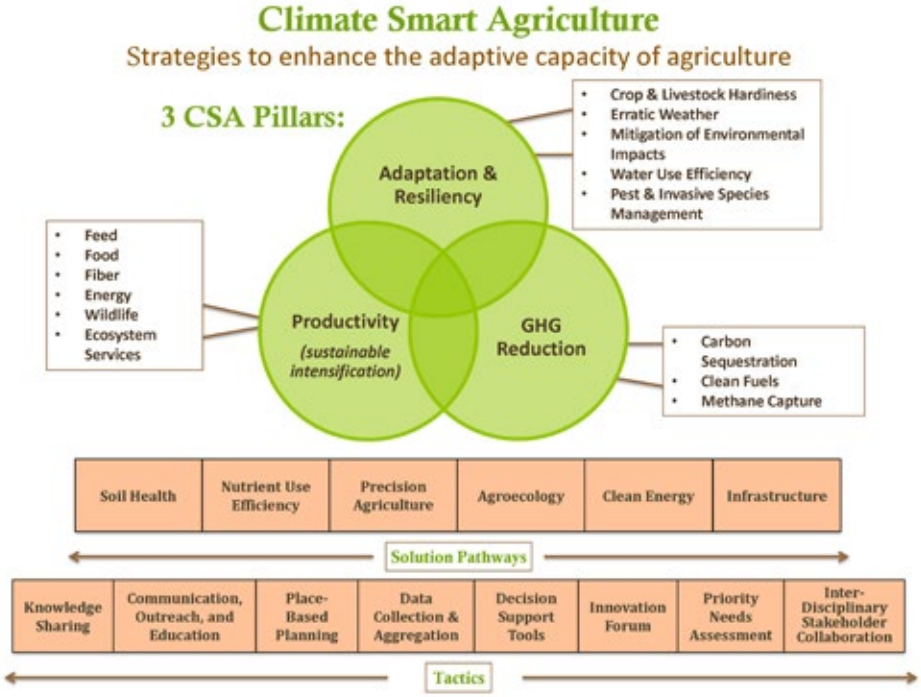


Figure 3 presents a visual depiction of specific strategies, tactics and solution pathways that can enable and scale agricultural and forestry contributions to attaining SDGs in Indiana as well as elsewhere in the U.S. and world.

That being said, the foundation of this model is built upon an all-encompassing need to adopt a "many pathways" and "all tools in the toolbox" approach to managing working lands that a) recognizes the tremendous diversity of agricultural landscapes and ecosystems within the state and b) enables producers to utilize the systems and practices that best support their own unique situations and circumstances. It also requires a recalibration of what and how we expect the land to produce.

The INSA Work Group believes that by letting farmers and foresters lead while focusing on the economic viability of managing working landscapes, policymakers can encourage win-win scenarios in which agriculture presents solutions for global challenges while improving environmental resilience, building strong rural communities, engaging consumers and enhancing public health through access to nutritious food.

It is essential that agricultural solutions are prioritized and enabled at the local, state and federal level in order to have a chance to meet environmental goals, including reestablishing and enhancing biodiversity on the land, while supporting producers' livelihoods.

PATHWAYS TO INDIANA'S SMART AGRICULTURE FUTURE

Photo credit: Conservation Cropping Systems Initiative

The good news is that the INSA Work Group believes that with planning and education, there are pragmatic actions that can be taken to help Indiana producers – even when faced with a changing climate – sustainably maintain and even intensify production, adapt and improve resilience, and concurrently deliver climate mitigation solutions.

Indiana's renewable energy assets, coupled with increased sequestration of carbon, offer high-value solution pathways. Forward-thinking policy-making and investments are needed to bring these solutions online quickly while balancing often competing priorities and interests among agricultural, energy and societal groups.

Adaptation Strategies

Adaptation strategies come in many different forms, but typically fall into three major categories:

1. Actions to increase resistance to changes in climate in order to maintain existing practices;
2. Actions to improve resilience by investing in steps that preempt disasters and restore systems in the wake of them; and
3. Actions to transform operations by diversifying production systems to incorporate ecosystem services that would transform the landscape and protect producer incomes in the face of significant changes in climate.

The INSA Work Group has identified and is recommending transformation adaptations to help Indiana producers diversity on-farm enterprises, production and markets; transition from linear to circular systems to make, use, recycle and reuse resources; and produce more than just commodities by managing their land and operations to deliver valuable and recognizable ecosystem services.

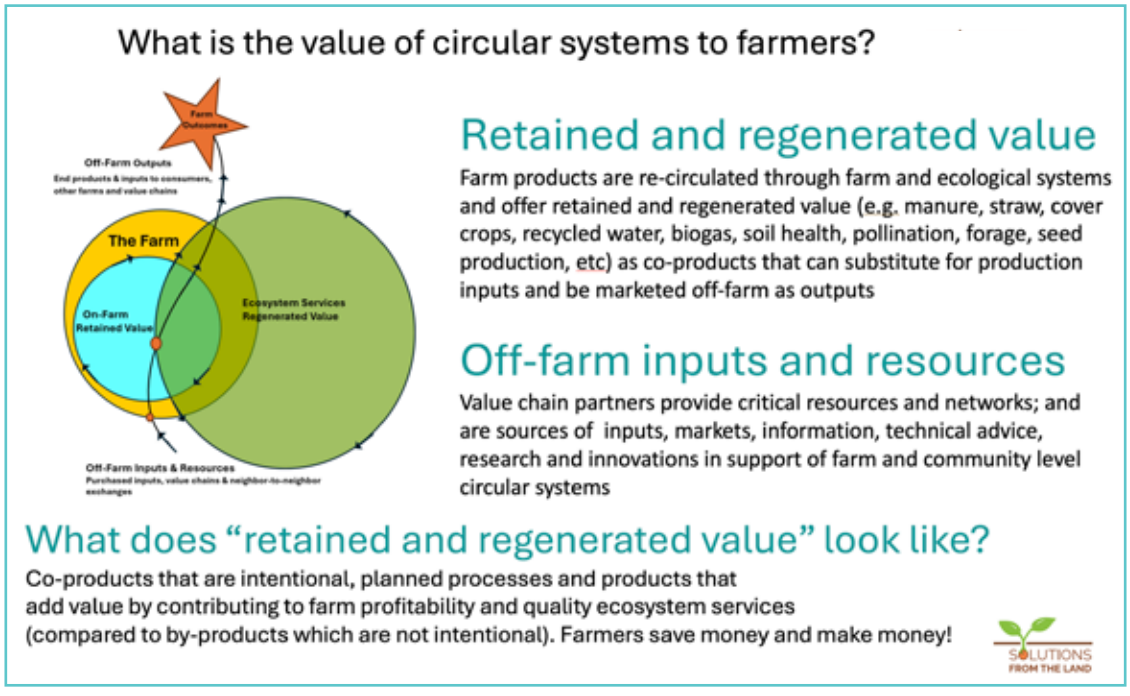


Figure 4. Farmers can save and make money by transitioning from linear to circular systems that make, use, recycle and reuse resources.

AGRORENEW: Turning Melons into Biodegradable Plastic

New Indiana Plant Will Convert Melon Waste to Sustainable Plastic Pellets.

More than 40 million pounds of watermelon, cantaloupe and pumpkin go to waste in Knox County, Indiana, fields each year. Most of those melons simply don't meet consumer expectations on appearance, and everyone loses out – especially the farmers.

Brian K. Southern learned about this food waste problem while volunteering his time offering office hours for entrepreneurs at The Pantheon Business Incubator in Vincennes, Indiana. As he visited with local farmers about the waste issue, he began asking himself and others: "How do we take this watermelon and turn it into something that is sustainable, viable that can be used to solve another problem?"

He and his wife, Katie Southern, a food scientist, began experimenting. They took watermelons back to the laboratory and crushed, pulverized, dried and ground up the rinds. They found the resulting material contained the carbohydrate traits required for resin production. The wasted melons could be used to create a biodegradable bioplastic!

The Southerns have since founded AgroRenew and plan to build a plant in Vincennes that will do just that. The facility is expected to produce more than 2 million pounds per day of 100% biodegradable plastic from melons classified as crop waste and rejects – none diverted from the food supply chain. The plant will source melons from local farmers as well as other melon-producing states, like Florida, Georgia, and Texas, through the newly formed AgroRenew Growers Limited, a co-op owned and controlled by the farmers who will sell their crop waste to AgroRenew.

At maximum capacity, the plant will employ more than 300 people and ship 300,000 tons of biodegradable plastic pellets annually for transformation into a variety of products, including plastic bags, hard plastics, straws and single-use packaging. Watermelon, cantaloupe and pumpkin feedstock will replace the fossil-fuel-based feedstock that typically goes into these plastic products, turning a crop waste problem into a climate change mitigation solution.

Don Villwock, a Knox County farmer and co-chair of the Indiana Smart Agriculture Work Group, has watched the Southerns' work evolve as he serves on The Pantheon's board of directors.

"I say it's a win-win-win," Villwock says of AgroRenew. "It's great for the environment. It's great for our local economy. And it's great for farmers."

Melons are often raised on fragile, sandy land, Villwock adds, and AgroRenew is working with land-grant universities, including Purdue University, to identify cover crops that could be grown between melon harvests and perhaps also be used as feedstock to maintain consistent, year-round production.

"It will be good for soil health, and it is another revenue source for farmers," he says. "We are excited about it, and we've got some very innovative farmers working with Brian, who just really believes in our community and wants to help farmers."

Photo credit: USDA/Preston Keyes

PATHWAYS TO INDIANA'S SMART AGRICULTURE FUTURE

I. PRACTICE CLIMATE SMART AGRICULTURE

II. GATHER AND DISSEMINATE INFORMATION

III. OPTIMIZE HUMAN AND TECHNOLOGICAL CAPITAL

IV. WISELY STEWARD SOIL AND WATER

V. ALIGN AND INTEGRATE GOALS

The Pathways

Based on the situations, opportunities and challenges we've outlined in this report, we are setting out five major pathways leading to Indiana's Smart Agriculture Future. Each pathway is followed by lists of needs and multiple associated action steps the Work Group proposes for consideration and discussion among the wide range of stakeholders we need to join forces and make them a reality.

The order in which they are presented here does not connote any ranking. We consider these recommendations to be interconnected and interdependent ways of ensuring that Indiana agriculture and all that it touches and enriches remains vibrant, innovative, resilient and productive for generations to come.

I. PRACTICE CLIMATE SMART AGRICULTURE

Scale up the adoption of climate-smart agriculture systems and practices.

- **Diversify, sustainably intensify and add value to the production of food, feed, fiber, energy and ecosystems services.**
  - » Develop a statewide market development action plan to help producers diversify their operations with identity-preserved, value-added production that enhances profitability and concurrently delivers ecosystems services.
  - » Create an interagency task force to construct and implement a finance and investment strategy that that will facilitate the development of infrastructure (processing, cold storage and distribution) and markets to meet growing demand for fresh produce, protein, fiber and forestry products.
  - » Relieve current bottlenecks at locker plants by providing funds via state appropriations and plant fees to hire additional state meat inspectors to allow for more and more diverse types of animals (e.g. small ruminants) to be raised and processed.
  - » Recalibrate the Indiana Department of Agriculture's Indiana Grown program by incorporating a diversification component with agronomic, market development, financing mechanisms and business plan support to help more producers make the first step toward diversifying production.
  - » Stimulate demand for Indiana Grown food by encouraging hospitals, schools and government institutions to buy locally.
  - » Quantify and report demand for locally produced food. Data can be used to justify and attract investments in support infrastructure and systems.
  - » Support development of new processing options for Indiana bio-products and the bioeconomy.

- **Improve adaptation, resilience and preparedness.**
  - » Expand research on herbicide-resistant weeds and new plant diseases and pests entering Indiana, along with research and development of crop varieties that exhibit greater resilience to abiotic stresses such as drought, heat and false springs.
  - » Expand testing and monitoring programs and train farmers what to look for and how to report weed, pest and disease observations.
  - » Step up surveillance and early action programs to combat and mitigate invasive plants and pests through enhancing cross-agency collaboration between the Indiana Department of Natural Resources and the Indiana State Department of Agriculture.
  - » Establish an early warning system to identify threats and cross-vector transmission pathways.
  - » Enhance collaboration among certified crops advisors, Extension agents and entomologists to plan and use integrated pest management and conservation biological control strategies.
- **Enable ecosystems services delivery.**
  - » Adopt circular bioeconomy production systems and practices that replace linear "take resources, make and dispose" strategies with circular "make, use, retain value and reuse" processes.
  - » Expand and fund research and Extension outreach work on circular systems and practices that enable farmers to produce food, feed, fiber and energy while concurrently filtering and storing water, enhancing biodiversity, sequestering carbon and producing other valuable ecosystem services that benefit themselves and the public.
  - » Explore pathways to accelerate and monetize the delivery of ecosystem services, including ways to:
    - Identify, define, quantify and value ecosystem services provided by a range of agricultural production systems and practices, to guide compensation and help farmers see the benefit to them and their operations.
    - Develop a market framework that works for producers.

NEW WEATHER PATTERNS BRING NEW PESTS

Red crown rot can appear as red discoloration on soybean stems.

Photo credit: Purdue University/Darcy Telenko

Red Crown Rot is Infecting Indiana Soybeans.

Just as climatologists track weather changes and their impacts on the state's agriculture, Indiana agronomists, weed scientists and plant pathologists are always on the lookout for new threats to crops in the state. Some of these increased weed, pest and disease pressures go hand-in-hand with climate change.

One of the newest intruders they've found is a disease called red crown rot (RCR) in soybeans and other legumes, caused by the soilborne fungus *Calonectria ilicicola.*

First detected in the state in 2022,[26] RCR symptoms can resemble sudden death syndrome or brown stem rot, all debilitating to affected plants. As of September 2024, RCR had been confirmed in six Indiana counties. Common in southern states for decades, it only started its spread to fields in parts of several Midwestern states in the last few years.

Purdue Extension plant pathologist Darcy Telenko, who works with farmers to identify this and other diseases in their fields, is tracking RCR with her colleagues across the Midwest as they learn more about it. Crop rotation of nonlegumes, like corn, may be useful for reducing the initial inoculation or survival of the disease, but a multifaceted management program will be necessary for future farming of soybeans.[27]

CLOSED-LOOP SYSTEM TURNS WASTE INTO NUTRITION AND ENERGY

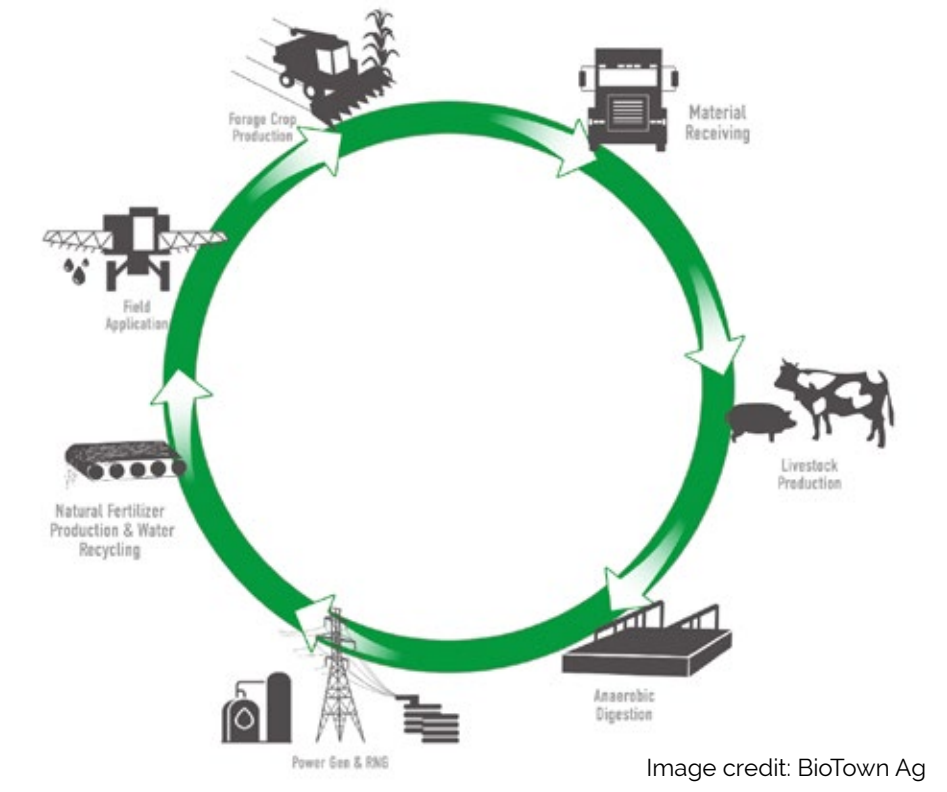


Image credit: BioTown Ag

With its circular agricultural practices, BioTown Biogas is turning manure into renewable energy and removing carbon from the atmosphere.

BioTown Ag and BioTown Biogas: Circular Bioeconomies in action.

For decades, the multi-generational family farm BioTown Ag in Reynolds, Indiana, has been a model of sustainability and the benefits and opportunities possible with a circular bioeconomy. Waste has always been seen as an opportunity to add value.

In recent years, BioTown Ag spun off its energy assets into BioTown Biogas (BTB). In 2023, BTB and Green Rock Energy Partners activated a new digester and processing facility, one of the largest on-farm biodigesters in the world. With its circular agricultural practices, BTB is turning manure into renewable energy and removing carbon from the atmosphere.

BTB sources food waste, dairy manure, beef manure and other agriculture waste to produce renewable natural gas and renewable electric power. The new facility, with two digesters, can generate more than 42 million kilowatt-hours of renewable power per year while also producing more than 3 million gallons of renewable fuel per year.

"We now produce more than enough electric power and natural gas to supply a town the size of Reynolds," Chad Hoerr, general manager of BTB, told the *Indiana Prairie Farmer* at the new facility launch. In addition, BTB markets carbon credits achieved by removing carbon during the conversion of manure to renewable energy.

The original BioTown Ag farm operation partners with food production companies, grocery stores and other similar companies, which bring their leftover food-grade materials to the farm. Some food wastes are mixed with silage and forage crops fed to the farm's beef cattle and hogs, others go directly into the BTB anaerobic digesters alongside the biological wastes produced by the livestock.

The nutrient-rich slurry left in the digester becomes fertilizer in both liquid and solid forms, which is applied to nearby corn and soybean farms as well as the fields that grow the silage and forage crops used to feed the farm's livestock. Water left over from the fertilizer manufacturing goes back to the digester to dilute materials or is used to irrigate crop fields. Solid leftovers become bedding for the beef barn. Nothing is wasted in the BioTown circular bioeconomy.

- Communicate and share knowledge about programs that incentivize and reward producers who provide ecosystem services.
- Develop metrics to quantify ecosystem service delivery.
- Develop a program to track the carbon intensity (CI) score of statewide production to document Indiana's competitive advantage over other production regions.

» Increase investments in forest health, primarily for private forests, but also for the large, contiguous blocks of state and federal forest land. We encourage efforts to:

- Reestablish a state technical and financial assistance program to help private land-owners improve forest health and properly manage their "40-year" crop.
- Direct a larger percentage of the Farm Bill EQIP money to forest landowners.
- Oppose non-management forestry policies that are harmful to forest diversity and that would eliminate oak/hickory regeneration.
- Support programs, such as those proposed by Indiana Soil and Water Conservation Districts and State of Indiana Cooperative Invasives Management, to fund invasive species mitigation.
- Promote all initiatives that promot science-based forest management.

II. GATHER AND DISSEMINATE INFORMATION

Expand research and knowledge-sharing to support and enable adaptation strategies.

- **Address information needs and gaps in priority topic areas by increasing state and federal investments in research into:**
  - » Impacts of climate change on weeds, disease, pests and animal health.
  - » Crop breeding to improve resilience, e.g., cultivars with improved dormancy that do not respond to brief winter and spring warm periods.
  - » Methane reduction strategies.
  - » Life-cycle analyses to ensure that value, inputs and outputs are properly scored.
  - » The value and importance of renewable natural gas and CO2 pipelines to Indiana agriculture.
- **Transform the way research is performed using more farmer/researcher co-design models.**
  - » Farmers need more conversations with researchers about what they need as opposed to the old way of having researchers approach farmers with solutions they think they need; research work and priorities need to be co-designed and identified.
- **Inventory and assess communication and knowledge-sharing efforts. The goal is to further enhance the effectiveness of existing programs that promote awareness among Indiana farmers and stakeholders of:**
  - » Climate data, forecasts and implications for Indiana agriculture.
  - » Resources and assistance available for climate smart agriculture, conservation and renewable energy practices.
  - » Adaptation and mitigation strategies.
- **Expand decision-support tools and programs.**
  - » Enhance monitoring to track climate impacts on crop yields and identify emerging trends.
  - » Assess economic impacts of climate change on the ag sector.
  - » Expand the Purdue Mesonet weather observation network, managed by the Indiana State Climate Office.
  - » Track and publish statewide data to assess progress, assist program planning and implementation, and better enable and ensure continuous improvement.

III. OPTIMIZE HUMAN AND TECHNOLOGICAL CAPITAL

Devise best ways to involve, support, enrich and protect the people who own, farm and work on Indiana's agricultural lands while also encouraging technological innovations and investment.

- **Organize and conduct an "Agricultural Workforce of the Future Summit."**
  - » Convened by the lieutenant governor, the summit can identify building blocks and resources needed to strengthen human capital and community resources.
  - » Engage all stakeholders — farmers, value chain partners, ag educators, 4-H and FFA leaders, Purdue University, community colleges.
  - » Key deliverable: a workforce development plan, including an access-to-land component to welcome and support the next generation of farmers and value-chain partners.
- **Develop a strategy/plan to help farm managers protect workers from heat stress and heat-related illnesses.**
- **Enhance collaboration between Purdue extension, ag retailers and other farm-service providers.**
- **Establish federal and state tax credits for technological investments farmers make that return ecosystem services for the common good.**
- **Support farmer mentor programs to facilitate cross-generational learning as older producers transition out of, and new producers enter into, agriculture in the coming decade and beyond.**

IV. WISELY STEWARD SOIL AND WATER

Protect and improve the health, quality and availability of soil and water on agricultural lands while helping producers deliver ecosystem services to the people of Indiana.

- **Develop a plan to increase state investments in conservation technical assistance and cost-share programs to help producers improve the sustainability of their operations while concurrently:**
- **Explore improve ways to further improve cross-boundary cooperation and collaboration.**
  - » Federal and state conservation agencies,
  - » Local soil & water conservation districts and
  - » Private-sector service providers to further help farmers manage their soil and water resources and scale up the delivery of ecosystem services.
- **Conduct a study to identify pathways to expand conservation easement programs targeted to non-productive land (waterways, wetlands, historically low-productivity sections of fields, etc.).**
- **Enhance water monitoring, data collection and reporting to inform farmer, policymaker and program decision-making.**

Photo credit: USDA/Brandon O'Connor

V. ALIGN AND INTEGRATE GOALS

Address the issues of often overlapping and competing goals for agriculture, clean energy and water management in Indiana through open communication, cooperation and planning.

- **Create an interagency task force to align state agencies toward effective and coordinated food, energy and water policies and programs.**
- **Develop a statewide comprehensive energy plan that:**
  - » Preserves local control over siting decisions for clean-energy facilities (solar, wind farms).
  - » Provides siting guidelines/guardrails to protect productive agricultural land.
  - » Includes incentives to direct development of new renewable energy-generation facilities away from important ag lands and on to hardscape areas.
  - » Establishes a solar mitigation program where developers of solar-generating sites pay a fee to raise funds that are then used to preserve agricultural land elsewhere in the state. The fee should be tied to the agricultural productive capability of the land used for solar — the more productive, the higher the fee.
  - » Incentivizes on-farm and regional distributed generation systems.
  - » Encourages agrivoltaics systems — the dual use of land for solar energy production and agriculture, such as grazing livestock and/or raising crops under solar panels.
  - » Creates renewable natural gas incentives for livestock producers (on-farm methane capture).
- **Develop a statewide water management plan that recognizes agriculture's contributions to the Indiana economy and the unique needs of the industry.**

A cover crop mix of cereal rye, crimson clover and rapeseed is aerially seeded over corn on no-till Indiana farmland that will be planted with soybeans in the spring.

Photo credit: NRCS/Brandon O'Connor

Climate change affects everyone, and no farming system – whether big, intermediate, or small; conventional, organic, or regenerative – will be untouched.

EPILOGUE

The Time to Act is NOW.

Despite Indiana agriculture's amazing evolution over time and impressive production statistics, our future is not assured. Changing climatic conditions, combined with other challenges, will erode the economic viability and environmental sustainability of farms, ranches and woodlands across the entire state. Climate change affects everyone, and no farming system – whether big, intermediate, or small; conventional, organic, or regenerative – will be untouched.

The good news is, however, there are pragmatic steps which can be taken to sustainably increase agricultural productivity and livelihoods; enhance adaptive capacity and improve resilience; and concurrently deliver ecosystem services, sequester carbon and reduce and/or avoid greenhouse gas emissions.

This is the opportunity side of the climate-change coin, and thankfully one that Indiana, with its storied academic institutions, centers of innovation and technology, conservation partnerships, and value chain collaboratives, is well positioned to capitalize on.

Given the speed and magnitude of the climate variation that is occurring here in Indiana, across the nation and the globe, there is no time to waste. The time for action is now, and we urge all agricultural stakeholders, which is everyone, to join the growing coalition of champions aligning to address this clear and present threat.

Photo credit: NRCS/Brandon O'Connor

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PURDUE UNIVERSITY | College of Agriculture

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