GGAA Field Trip

Wednesday, June 8 | 6:30am – 6:00pm

Archbold Biological Station & Buck Island Ranch

In pursuit of sustainable food production, the U.S. Department of Agriculture (USDA) launched the Long-Term Agroecosystem (LTAR) network, comprised of 18 locations across the U.S. These sites work together to address national and local agricultural priorities and advance the sustainable intensification of U.S. agriculture. The **Archbold Biological Station/University of Florida** is one of these sites and is used to develop and assess sustainable agricultural production systems that integrate environmental and socio-economic needs from local, regional, to national scales.

Co-located at this site is **Buck Island Ranch,** a 10,500 acre cattle ranch among the top-20 commercial cow-calf producers in Florida. Its herd is ~3,000 Brahman-cross cows bred to 150 Angus or Charolais bulls. Over 2,300 calves are raised annually and subsist mainly on grass in the summer but are supplemented with feed in the winter and free choice mineral year-round.

FIELD TRIP ITINERARY

7:30am	Buses Depart Hotel
9:45AM	BUSES ARRIVE –get off, stretch, restroom break
	Attendees divided into two groups of 45
	ARCHBOLD Welcome group
10:00am–2:30pm	Presentations, demonstrations, and a swamp buggy tour by Archbold Scientists
12:00pm–1:00pm	Break for Lunch and a Group Photo
2:30pm–3:00pm	Farewell and Board Buses
6:00pm	Arrive back at host hotel

During the Tour

Archbold scientists will give presentations and demonstrations sharing their latest research on ecosystem and cattle GHG emissions and measurements, including supplemental feed and enzymes research. You will board a Swamp Buggy and tour several sites on the ranch where ecosystem GHG monitoring is being conducted. You will also get to see a typical Florida beef cow/calf production system in operation.

We invite you to peruse the following pages provided by Archbold to give you plenty of background prior to arrival so you can make the most of what you'll explore at the station.

Bottled water and snacks are available on the bus and will be provided throughout the tour at Archbold. If you need help at any time during the tour, please ask a volunteer for assistance.

Enjoy Your Trip!

Gases, Grasses, and Cows

Originally published in Florida Cattleman and Livestock Journal, September 2020.

Shared with permission from the Florida Cattlemen's Association, written in conjunction with 2020-2021 President, Gene Lollis.

by Dr. Betsey Boughton, Dr. Grégory Sonnier and Dr. Hilary Swain, Archbold Biological Station

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The new Burger King commercial on methane is a sign that the food industry has recognized consumers are paying more attention to where their food is coming from and the impacts of agriculture on the environment. As scientists, we were surprised that the commercial emphasized methane emissions from the 'rear' of the cow. In fact, most cattle methane emissions come from cow burps! It is true that agriculture can be a large source of carbon and other greenhouse gases to the atmosphere and there is a push for the industry to reduce carbon emissions to be more sustainable. We agree with the Burger King statement that "since we are part of the problem, we are working to be part of the solution." Continually improving the sustainability of our Florida cow-calf operations is an important goal, for both economic and environmental outcomes–however, the full picture of carbon dynamics is very complex and won't fit very nicely into a cute song for a commercial!

Cattle grazing on improved pasture (top) and semi-native pasture (below). Photo by P. Bohlen.

At Buck Island Ranch, we have been working with collaborators from Cornell University, University of Illinois, University of Florida, USDA, and recently, the private feed company Alltech, to better understand the carbon cycle on Florida cow-calf operations. The carbon cycle on Florida ranches is complex because we must consider both sources of greenhouse gases (cattle, fire, fertilizer, soils, wetlands, etc.) and sinks of greenhouse gases (wetlands, grasslands, soils, and woodlands). We focused the last 7 years of work on two important greenhouse gases, carbon dioxide, and methane. Methane has a global warming potential that is 25x the strength of carbon dioxide.

This work requires very advanced technologies measuring atmosphere, soils, water, plants, and cattle movements, together with the scientists needed to manage and analyze the huge amounts of data collected. Research at Buck Island Ranch has shown that grazed pastures are a net sink for carbon dioxide, meaning these pastures absorb more carbon dioxide through photosynthesis than they release through respiration. Furthermore, we compared the carbon budgets of grazed and ungrazed semi-native (unimproved) pastures and showed that grazed pastures were a greater carbon sink than the ungrazed pastures, even after accounting for methane produced by cattle. The reason that the grazed pastures were a greater sink was due to two things. First, there were more green leaves in grazed areas (allowing more photosynthesis). Second, in ungrazed pastures, dead vegetation built up and led to more respiration from microbes (microbes release carbon dioxide). Our research has also shown that wetlands and wet soils are a major natural source of methane in our subtropical pastures, while cattle were responsible for only 19-30% of the annual methane emissions. This result is important because cattle emissions are generally considered the dominant component of pasture methane budgets, but this was not true for these subtropical pastures. An emerging and complex area of research at Buck Island Ranch is to understand how forage availability and its nutritive value drive cattle greenhouse gas emissions, largely methane via enteric fermentation (microorganisms breaking down forage in cow rumens). Under our new research alliance with Alltech, we are beginning to explore how pasture management is influencing forage nutritive value and carbon dioxide and methane emissions during digestion. We found that prescribed burns tend to increase forage nutritive value and that semi-native pastures have similar forage value as improved pastures during the dry season. We also found that better quality forage led to lower carbon dioxide and methane emissions per gram of biomass digested.

This year we will be exploring if adding specific enzyme supplements increases forage digestibility and energy intake for the cow, while decreasing carbon dioxide and methane emissions. We will be sure to ask Alltech scientists what they think about adding lemongrass to cattle feed, since the Burger King commercial suggested that adding lemongrass to cattle feed reduced methane emissions by 1/3.

Buck Island Ranch staff make adjustments to an eddy covariance tower that measures carbon uptake and emissions from the grassland. Photo by Carlton Ward, Jr.

As agriculture comes under increasing scrutiny regarding greenhouse gases, data such as these are important information for Florida ranchers. As we move forward, we must consider both the *sources* and the *sinks* of the greenhouse gases. Our pastures, wetlands, and forests play a huge role, and we must not overlook their importance. Also grazing and fire are management tools that can significantly enhance the carbon sink strength of the land. Our research on the carbon cycle and greenhouse gases is ongoing and we are currently analyzing the effects of prescribed burns. In the coming year, the Archbold-Alltech Research Alliance is planning to quantify the carbon footprint of BIR's cattle operation and explore the possibility for carbon credits, assessing these as another potential source of funding for ranch operations.

Harnessing fire and grazing to enhance cattle distribution, forage, and carbon capture

Originally published in Florida Cattleman and Livestock Journal, March 2021

Shared with permission from the Florida Cattlemen's Association, written in conjunction with 2020-2021 President, Gene Lollis.

By Dr. Betsey Boughton, Dr. Hilary Swain, and Dr. Raoul Boughton, Archbold Biological Station

Fire has shaped Florida's ecosystems for thousands of years. Before humans arrived, lightning ignited fires would occur frequently across the southeastern US. Florida's plants and animals are adapted to fire and without fire natural habitat quality declines. For hundreds of years, Florida cattle ranchers managed fire in grasslands, prairies, and flatwoods, even during times when government policies were to suppress fires and when it was popular to suppress. If ranchers and foresters had not been using fire for land management over the past hundreds of years, our Florida landscape would look a lot different and the number of plant and animal species we see today would be drastically reduced. Floridians are fortunate that ranchers kept burning and maintained a tradition of fire!

Cattle production goes hand in hand with the controlled use of fire. It is a widely known that cattle and other grazing animals, like bison, are attracted to the re-growing forage in recently burned areas. Our research at Buck Island Ranch has shown that after a fire, forage has higher crude protein, digestibility, and phosphorus compared to unburned vegetation. The increased forage nutritive value lasts for 100 – 200 days' post fire but the response can vary by year and may depend on moisture conditions. For the last few years, scientists at Buck Island Ranch have been investigating how controlled fire can be used in pastures to influence cattle behavior, distribution, and use, and how fire and grazing interact to affect forage value and carbon capture.

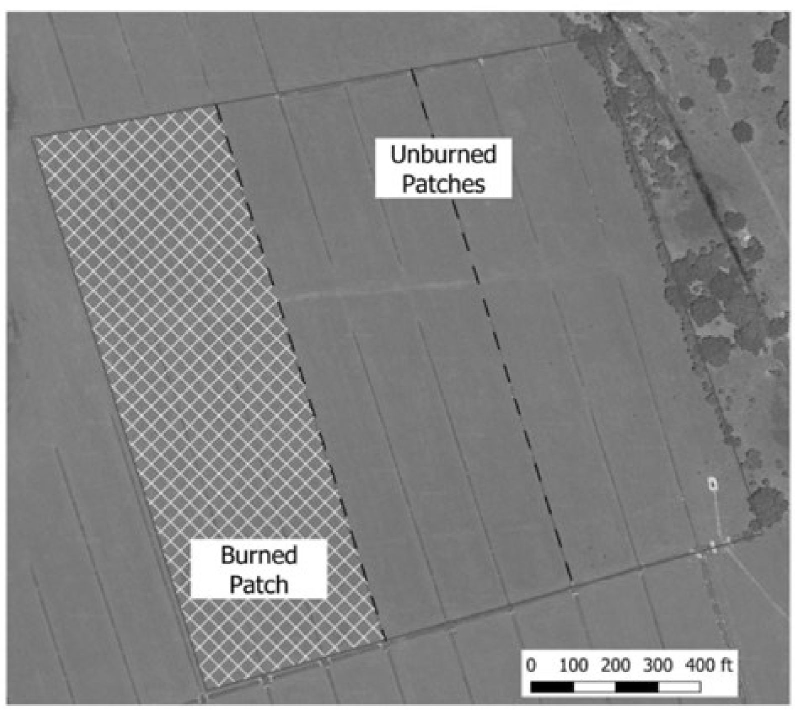


Figure 1. An example of a "patch burn" pasture. White cross hatches indicate recently burned patch. Red boundary lines are fence lines. Black dash lines indicate interior pasture patches.

In our study, funded by the USDA, we applied two different controlled burn methods to 16 experimental pastures. In the first method, full-burn, we burned the entire pasture once in a three-year period; with the first burn in 2017. In the second method we burned a different one-third of the pasture each year in rotation (Figure 1). This second method has commonly been called 'patch-burn grazing'. Rotational use of fire in pastures helps prevent overgrazing a burned patch over consecutive years. Both methods allow us to put fire on the ground, which helps reduce woody plants and remove dormant, less nutritious thatch and grass. Patch-burn grazing has been used for many years by Florida's ranchers, who often conduct intermittent patchy burns, though there may not have been a formal name for the practice. Patch-burn grazing has also been applied for both conservation and cattle production purposes in the Great Plains region.

Cattle were equipped with GPS units to track their movement within pastures. In Buck Island Ranch's semi-native pastures for each year of the study (2017-2019), cattle in the patch-burn group spent more time grazing in the 1/3rd burned patch compared to the 2/3rd unburned patches of the pasture (Figure 2A). In contrast, in the semi-native full-burned pastures, cattle seemed to favor certain areas of the pastures consistently across all three years of the study (Fig. 2B). Meanwhile, in improved pastures treated with patch burning we saw weak to little effect of cattle utilizing patch-burned areas (Figure 2C), and in the improved pasture full-burned treatments, cattle utilized the different thirds of the pastures equally (Figure 2D). These results suggest we can use patch burns in semi-native pastures to make areas more attractive to cattle and encourage them to utilize different areas of these pastures that they might otherwise avoid, but this is not effective in improved pastures.

The use of controlled fire can provide many benefits to ranchers and wildlife. These benefits include the reduction of woody plants and improved forage nutritive value along with the ability to attract cattle to other parts of the pasture they might avoid. Burning a different patch of a pasture each year leads to an annual bump in forage nutritive value every year while full burning on a 3-year interval only provides the bump in forage nutritive value once every 3 years. Patch-burn grazing also benefits habitat for wildlife species since cattle will graze disproportionately in recently burned patches, reducing the grazing pressure on unburned areas leading to taller grasses that can provide shelter for wildlife. By creating both short grass and tall grass areas, patch-burn grazing can fulfill the requirements of a greater variety of bird species. During this same study, Archbold's collaborators from University of Illinois measured carbon capture in the two burn regimes. The first results coming in from the semi-native pastures suggest that the practice of patch-burn grazing enhances pasture uptake of carbon compared to the practice of full burns. Our data analysis is not yet complete in improved pastures.

More results will be coming out soon as well as an economic analysis. Please contact Betsey Boughton at eboughton@archbold-station.org for more information, we would love to hear your thoughts about the practice of patch-burning.

USDA ARS

ARCHBOLD
BUCK ISLAND RANCH

Cornell University

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

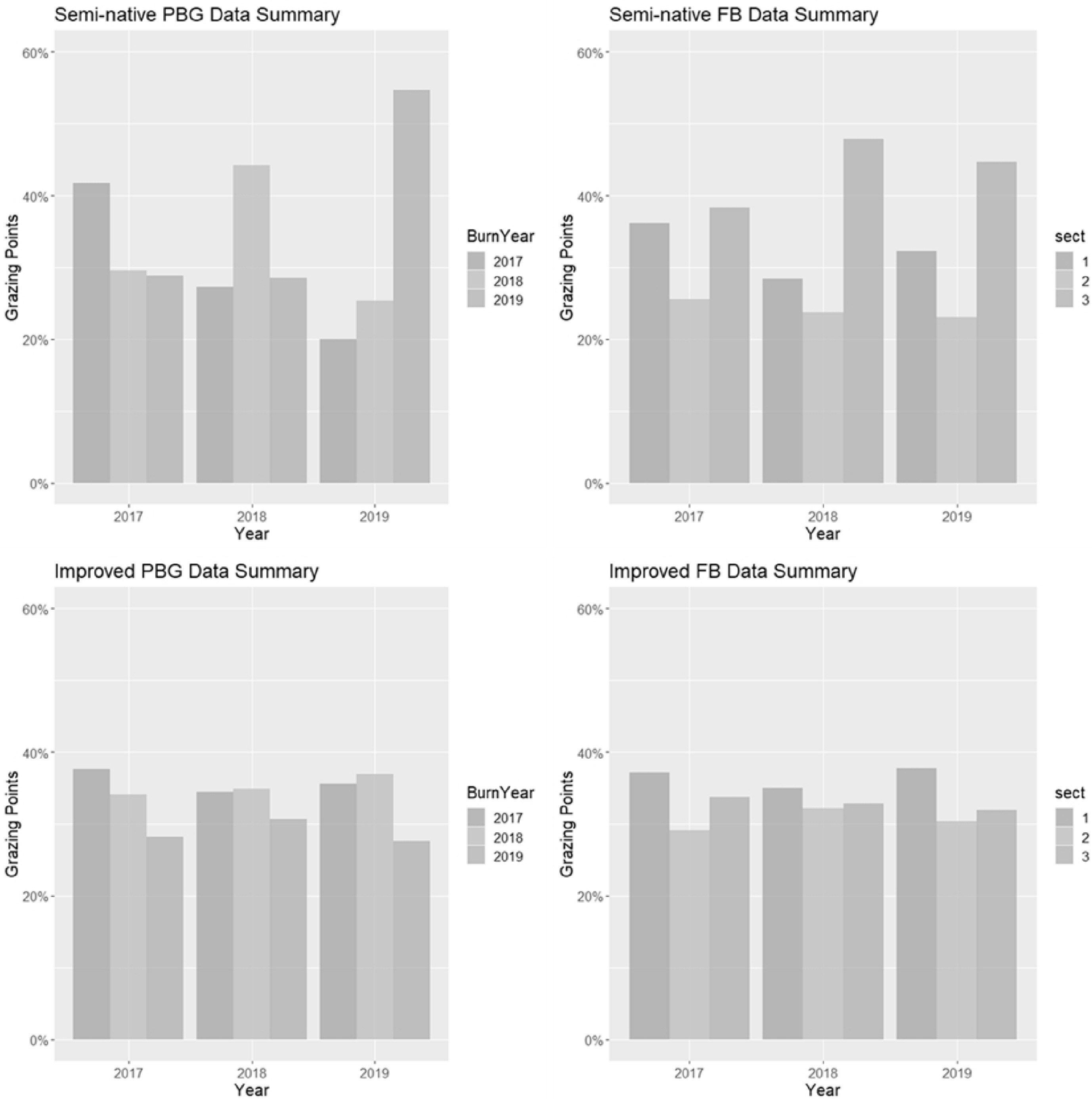
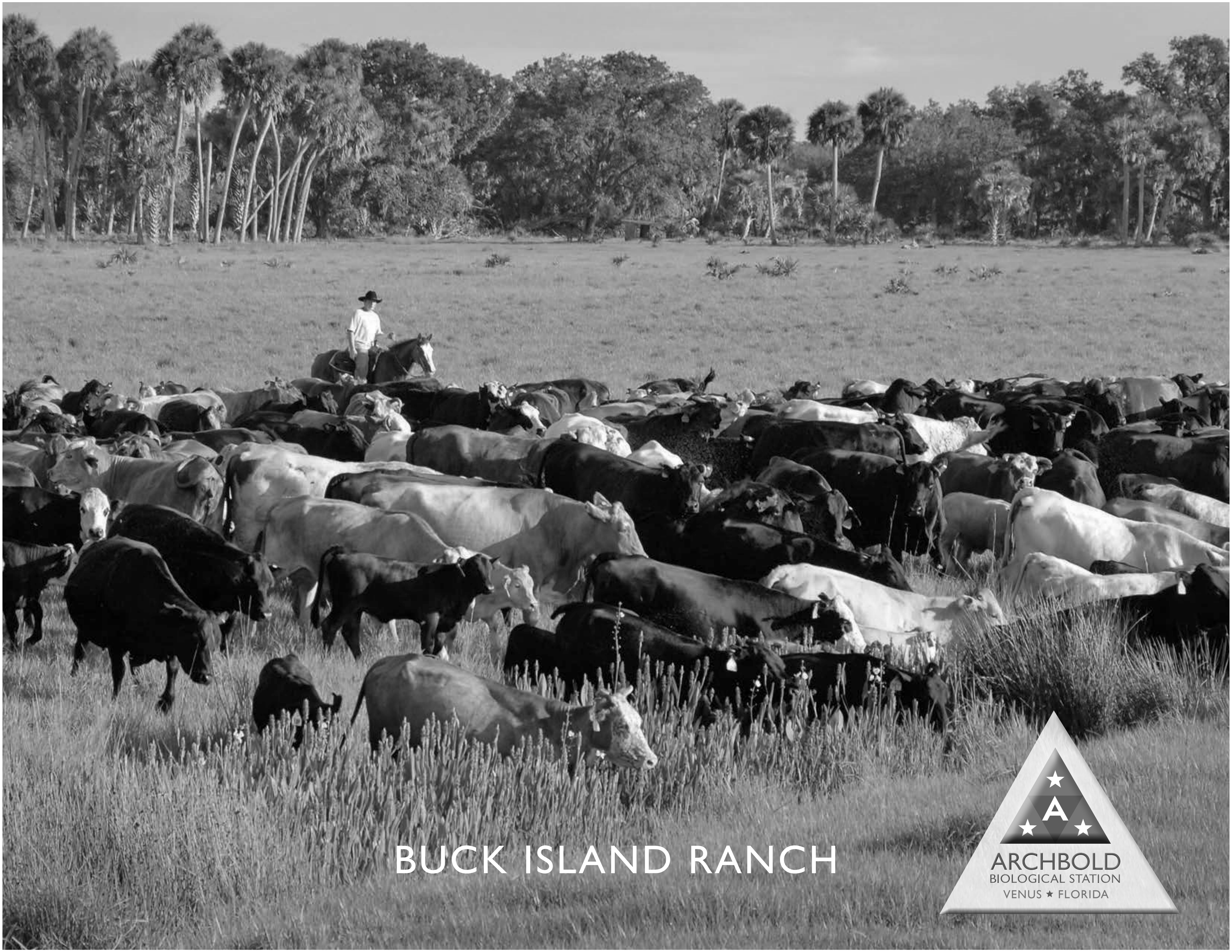


Figure 2. Annual average grazing points recorded by cattle GPS collars in patch-burn pastures (PBG) and full burn pastures (FB) in semi-native and improved pastures at Buck Island Ranch. Patch burns had a striking effect on cattle behavior in semi-native pastures (A), while in improved pastures there were weak to no effects (C). In full burn treatments within semi-native pastures, cattle consistently favored the same areas each year of the study (B). Cattle used each sector (third of a pasture) in full burn treatments relatively equally in improved pastures (D).


BUCK ISLAND RANCH
ARCHBOLD
BIOLOGICAL STATION
VENUS ★ FLORIDA

SCIENTIFIC RESEARCH

For decades Archbold Biological Station has been an internationally recognized nonprofit organization dedicated to in-depth research, education, and conservation in the heart of Florida, one of the world's most ecologically diverse regions.

This subtropical heart of Florida is home to plants and animals found nowhere else on Earth. It is also home to the rich cultural history of American cattle ranching that began in Florida in the 16th century. Today Florida boasts some of the largest ranches in the United States (many owned by fifth and sixth generation Floridians) that contribute billions of dollars annually to the state economy, and exist on lands of significant ecological importance.

This unique mix of economic, cultural, and environmental values offers a fertile natural laboratory to help solve a crucial 21st century global challenge: how to develop sustainable agricultural and land management practices that will honor natural biodiversity and the services nature provides while remaining economically viable for generations to come. Archbold's highly respected research teams are developing insights and offering solutions to this question.

In 1988, with a strategic goal to explore these challenges, Archbold leased the10,500-acre Buck Island Ranch from the John D. and Catherine T. MacArthur Foundation, establishing the MacArthur Agro-ecology Research Center. Buck Island Ranch is one of a handful of working cattle ranches worldwide with such an intense and successful history focused on "hands-on" agro-ecology research and conservation.

FROM RIDGE, TO RANCH, TO RIVER

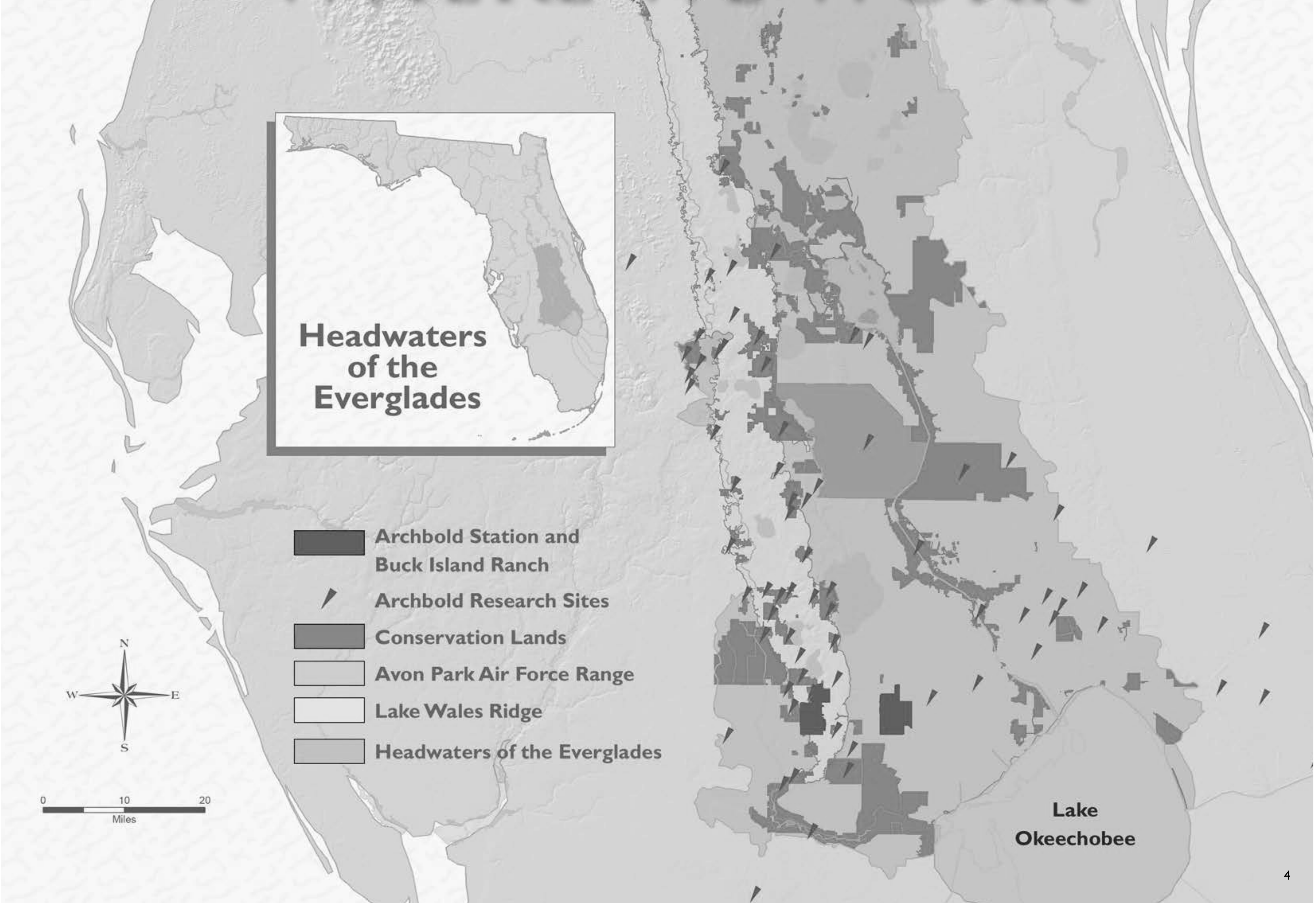
The heart of Florida is a 2.6 million-acre watershed, the Headwaters of the Everglades, that stretches from the ancient sands of the Lake Wales Ridge, across nearly one million acres of working cattle ranches to the rivers that flow south into Lake Okeechobee and beyond, to the Everglades and the coasts.

Archbold conducts its work at the 8,848-acre Station on the southern end of the Lake Wales Ridge and at the10,500-acre Buck Island Ranch, as well as at more than 70 other diverse research sites ranging from pristine conservation lands to other private ranches.

The agro-ecology research program at Buck Island Ranch, driven by Archbold scientists and collaborators from universities and government agencies, is a vital part of Archbold's integrated research, education, and conservation mission with the power to affect the lives of millions of people in Florida and around the world.

> *Once Buck Island Ranch became aligned with Archbold, it became a valuable partner in helping the cattle industry understand and embrace sustainable ranching practices. They have built a wonderful communication bridge between us and the non-ranching community.*
>
> JIM HANDLEY, EXECUTIVE DIRECTOR
> FLORIDA CATTLEMEN'S ASSOCIATION

WHERE WE WORK



YESTERDAY

John D. MacArthur

Florida is the oldest, and one of the largest, cattle-producing states in America, and Buck Island Ranch is emblematic of this rich ranching history. Five hundred years ago Spanish explorers introduced cattle to Florida. Ranching continues today as a vibrant part of Florida's economy, culture, and heritage.

John D. MacArthur, billionaire business man who developed Bankers Life and Casualty Company, purchased Buck Island Ranch in 1968. He died in 1978 and for the last ten years of his life, he enjoyed what his long-time ranch manager, Dan Childs, said were his treasured "walks in the woods on the Ranch."

L to R Tony Cunha (University of Florida), J. D. MacArthur, and Dan Childs, 1970s.

Buck Island Ranch Cattle Brand

> *He loved this place. He'd be very proud of the fact that it is still a ranch, and that you (Archbold) are doing what you are doing...and I know he would want to keep it as a ranch.*
>
> DAN CHILDS
> RANCH MANAGER, BUCK ISLAND RANCH, 1968-1996

TODAY

10,500 acres leased from the MacArthur Foundation to provide a living natural laboratory for ecological research

3,763 acres on the Ranch protected under conservation easements

722 plant and vertebrate animal species recorded on the Ranch, 45% of those found in Central Florida

179 scientific publications based on MAERC research, to date

33 Masters Theses and Ph.D. Dissertations based on research conducted at MAERC, to date

68 post-baccalaureate interns trained in agro-ecology research at the Ranch, to date

6 federally threatened or endangered species make their home on the Ranch, including Gopher Tortoise, Eastern Indigo Snake, Crested Caracara, Wood Stork, Snail Kite, and Florida Panther

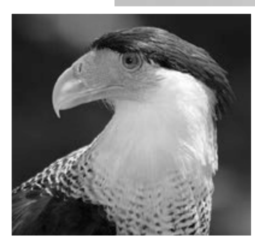
3,000 cows at Buck Island Ranch, among the top 20 Florida beef cow-calf producers

100's of ranchers, land managers, and other professionals attend workshops and tours annually

SNAPSHOTS OF SOLUTIONS

CONSERVING BIODIVERSITY

A study extending back more than 20 years of the federally threatened Crested Caracara verified this raptor's dependence upon ranches in the heart of Florida, documented the stability of the population, and concluded that their long-term survival depends upon maintaining ranchlands, rather than conversion to crops or urban development. The study demonstrated the meaningful role ranchlands play in conserving biodiversity.



MAINTAINING ECOSYSTEM PROCESSES

Arcbhold was among the key leaders of a collaborative state and national partnership that provides incentives for ranchers to implement strategies to slow the flow of water from their working lands, thereby reducing damaging flows and nutrients downstream. It is one of the first truly market-based payments for environmental services programs in the country.

SNAPSHOTS OF SOLUTIONS

ENHANCING LAND MANAGEMENT

An ongoing experimental study of 40 wetlands at Buck Island Ranch is revealing the long-term impacts of land management decisions and informing best practices for wetland preservation and restoration. The study results to date show that intentional (controlled) fires or moderate cattle grazing are needed to preserve a diversity of native wetland plants. The absence of these practices results in wetland degradation.

ADDRESSING INVASIVE SPECIES

Wild hogs are a rampant, invasive species in the heart of Florida. The University of Florida, together with Archbold, is leading an interdisciplinary study on the habits of hogs and, with the help of of remote cameras, GPS, and genetic sequencing technology, is identifying potential emerging diseases and the likelihood of transmission to domestic cattle or other native animals.

ANTICIPATING CLIMATE CHANGE

Through extensive field work and the deployment of advanced instrumentation, cycles of greenhouse gases are being accurately measured on Buck Island Ranch pastures and wetlands. Initial analyses suggest that pastures are a sink for CO_2 and grazing by cattle can increase CO_2 uptake by the ecosystem. The work also found that wetland soils are a large contributor of methane, an important greenhouse gas. These data are informing global climate models.

ENDURING IMPACT

SNAPSHOTS OF SUCCESS

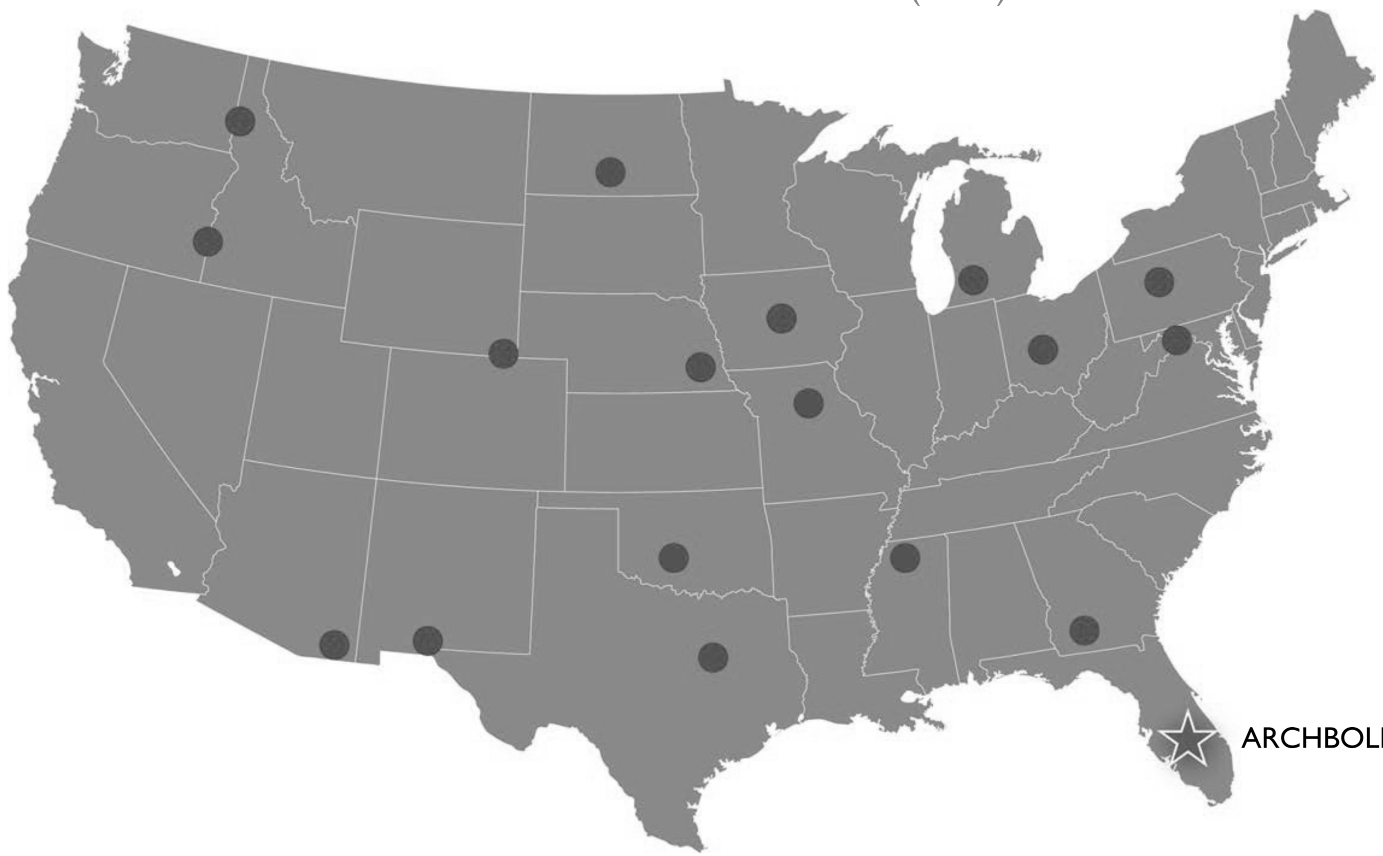
PROVIDING LEARNING EXPERIENCES

To date, nearly 70 post-baccalaureate research interns have "graduated" from the intensive 6- to 12-month intern program at Archbold's Buck Island Ranch. They have gone on to become rising stars in the science, agriculture, and conservation communities. They are the scientists of tomorrow who will help solve our most critical environmental challenges.

FOSTERING STEWARDSHIP

Our Ranch leadership team has been recognized across the state and nationally with awards for promoting innovations in the ranching industry, for protecting Florida's heritage, and for outstanding environmental stewardship.

U.S. DEPARTMENT OF AGRICULTURE
LONG-TERM AGRO-ECOSYSTEM RESEARCH (LTAR) NETWORK

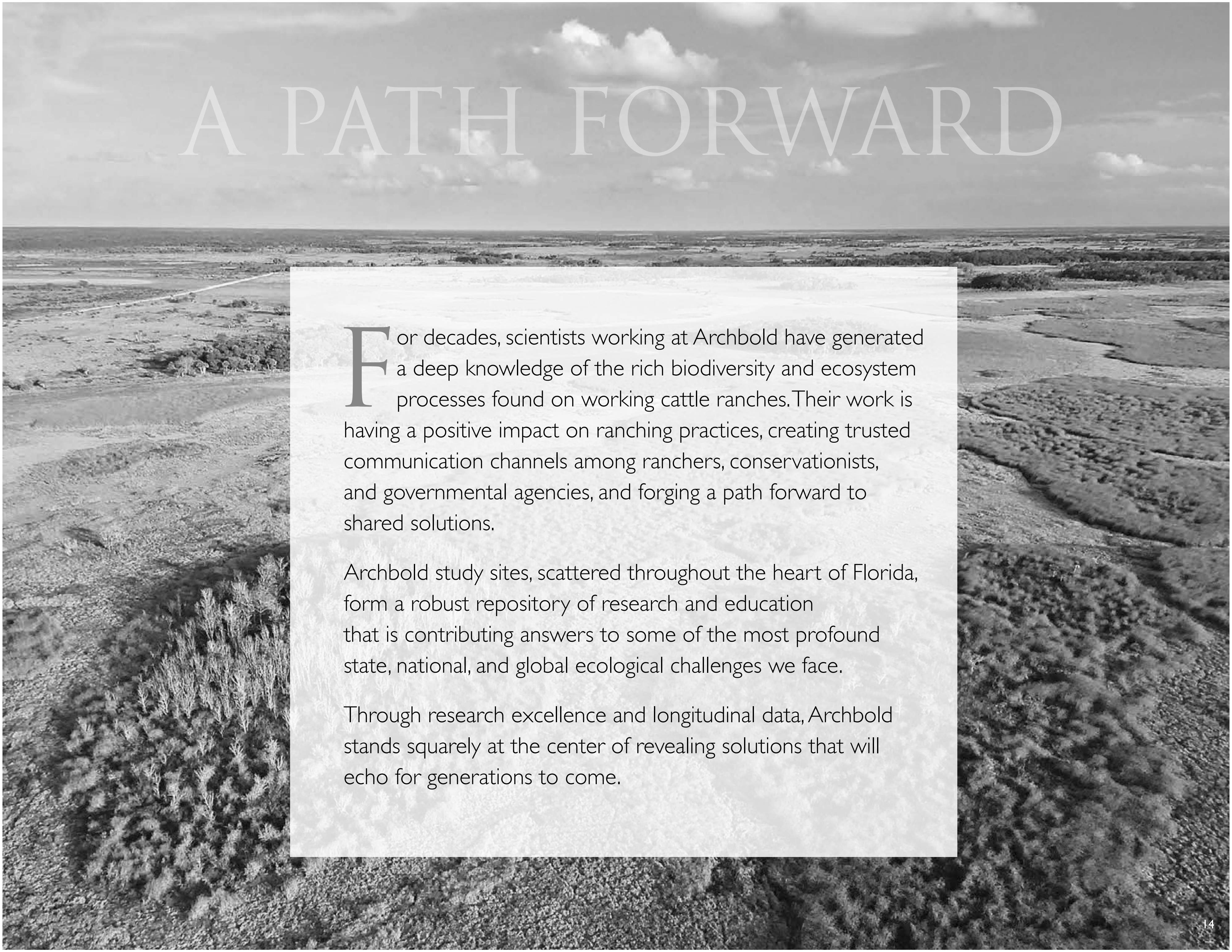


ENGAGING ON THE NATIONAL AND THE GLOBAL STAGE

Archbold, with our partners at the University of Florida, were selected by the U.S Department of Agriculture to be a part of a network of 18 sites for a 30-year national research program that will produce the knowledge to improve both agricultural sustainability and the delivery of ecosystem services to a society that increasingly demands that agriculture be safe, environmentally sound, and socially responsible, in addition to being productive and economically viable.

"For more than 30 years, the USDA NRCS and our private landowner clientele, have benefited greatly from our relationship with Buck Island Ranch and Archbold—whether it be working on grazing lands, conservation, wetland restoration, water quality, invasive plant species control, or the protection of threatened and endangered species."

GREG HENDRICKS, STATE RESOURCE CONSERVATIONIST, RETIRED
US DEPARTMENT OF AGRICULTURE, NATURAL RESOURCES CONSERVATION SERVICE (USDA, NRCS)



A PATH FORWARD

For decades, scientists working at Archbold have generated a deep knowledge of the rich biodiversity and ecosystem processes found on working cattle ranches. Their work is having a positive impact on ranching practices, creating trusted communication channels among ranchers, conservationists, and governmental agencies, and forging a path forward to shared solutions.

Archbold study sites, scattered throughout the heart of Florida, form a robust repository of research and education that is contributing answers to some of the most profound state, national, and global ecological challenges we face.

Through research excellence and longitudinal data, Archbold stands squarely at the center of revealing solutions that will echo for generations to come.

"COWBOYS & SCIENTISTS"
•
"THE SCIENCE OF A FLORIDA RANCH"

ARCHBOLD
BIOLOGICAL STATION
•
BUCK ISLAND RANCH

"Cowboys & Scientists"

Thirty years ago, a partnership between Archbold Biological Station and Buck Island Ranch inspired a new mission: cowboys and scientists working together to advance scientific discovery on a ten thousand acre working cattle ranch. Bridging this cultural divide has resulted in a series of transformative discoveries that have begun to reshape our misconceptions about agriculture, sustainability, and conservation in the 21st century.

Watch the film by visiting: https://vimeo.com/284845287

"The Science Of A Florida Ranch"

The scientists work together with the ranchers in the fields where agriculture is occurring. The Ranch is their lab. For three decades, Buck Island Ranch cowboys partnered with scientists at Archbold to understand the ecology of a working cattle ranch.

Our new film "The Science of a Florida Ranch" tells the story of how this visionary marriage between old Florida ranching and modern day science will ensure the survival of wild Florida.

Watch the film by visiting: https://vimeo.com/329180054

Buck Island Ranch Purchase

Archbold is pleased to announce that we have taken advantage of a tremendous opportunity—to purchase Buck Island Ranch from the John D. and Catherine T. MacArthur Foundation, making the Ranch part of Archbold forever. In 1988, Archbold leased the 10,500-acre Buck Island Ranch from the MacArthur Foundation. For decades the ranch has provided a unique mix of economic, cultural, and environmental values, serving as a natural laboratory where Archbold could address a crucial 21st century global challenge: how to develop sustainable agricultural practices that will honor natural biodiversity and the services nature provides while remaining economically viable for generations to come. Archbold's highly respected research teams and collaborators have developed insights and offered solutions to this challenge.

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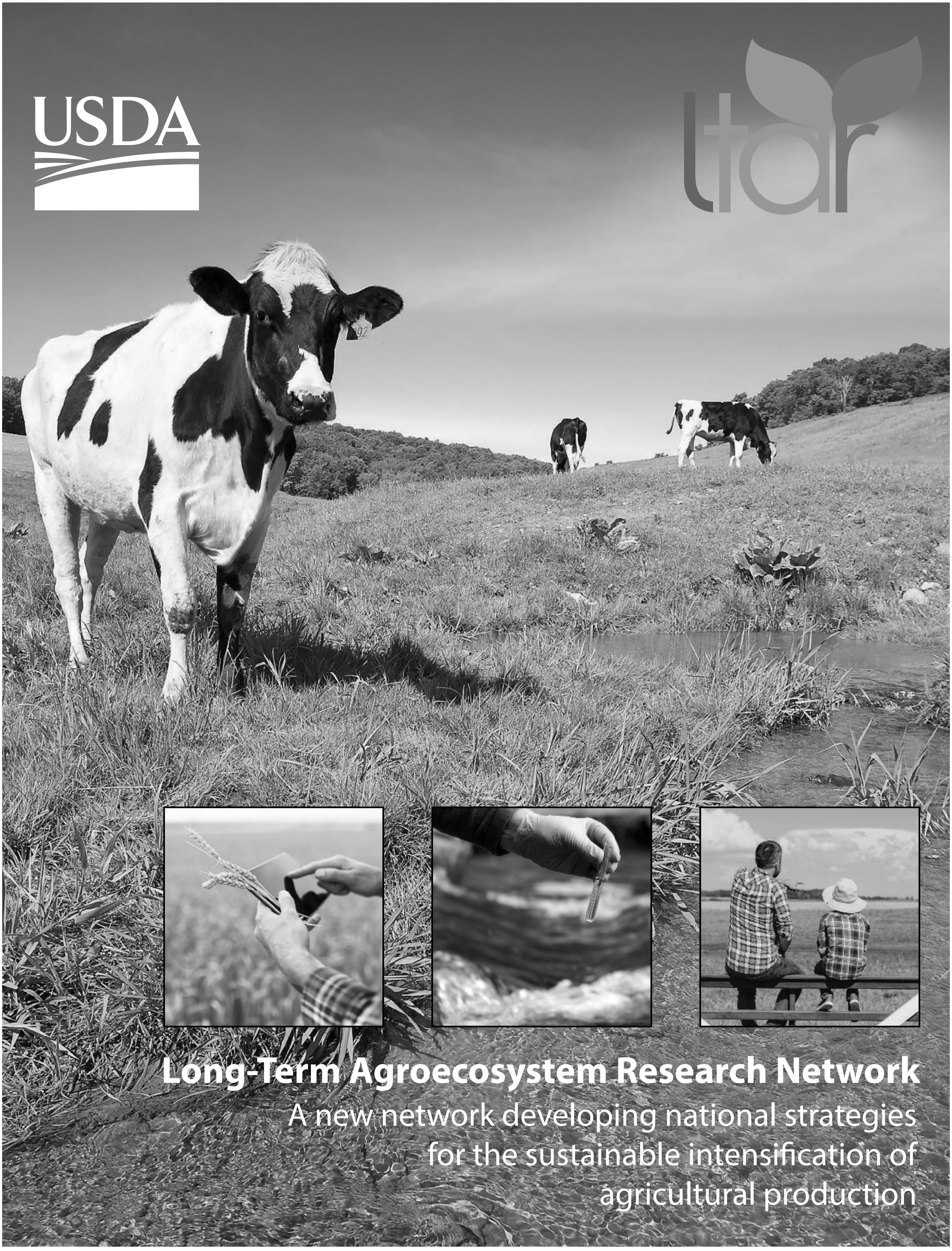
Contact Information
Zach Forsburg
Communications Coordinator
zforsburg@archbold-station.org

Visit our website
or YouTube to view the films:
https://www.youtube.com/user/ArchboldExpeditions



Long-Term Agroecosystem Research Network

A new network developing national strategies for the sustainable intensification of agricultural production

Notes from the Agricultural Research Service Office of National Programs

Teferi Tsegaye, PhD
LTAR Network
National Program Leader

All of us want safe and nutritious food, clean water to drink, and clean air to breathe. We also yearn for health and well-being, comfort, prosperity, and the ability to pass these amenities to our children and descendants. Agriculture not only provides our food, but it is the link that connects us to our legacy, because all life is inextricably linked in the great web of ecosystem services that is Planet Earth.

Thus, the LTAR network was created to make certain this link is never broken by developing the science to ensure that agriculture is sustainable and capable of providing for our needs long into the future.

The LTAR network also recognizes that a limit exists to how many living organisms Planet Earth can support under current conditions and management strategies. The overarching purpose of the LTAR network is to ensure that science addresses not only enhancing production, but also protecting the environment, sustaining ecosystem services, and promoting rural prosperity.

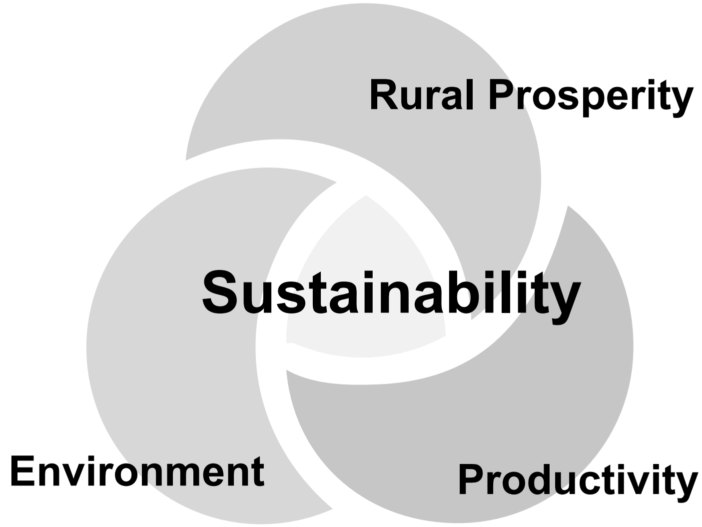
Teferi Tsegaye
teferi.tsegaye@ars.usda.gov

The Sustainable Intensification of U.S. Agriculture

Agriculture in the United States must respond to escalating demands for productivity and efficiency, as well as pressures to improve its stewardship of natural resources. Growing global population and changing diets, combined with a greater societal awareness of agriculture's role in delivering ecosystem services beyond food, feed, fiber, and energy production, require a comprehensive perspective on where and how U.S. agriculture can be intensified sustainably.

Agricultural intensification involves increasing production while optimizing the use of system resources. However, intensification also needs to be sustainable. This can be be done by balancing increased production with the need to conserve natural resources and to protect the environment while promoting rural prosperity.

Sustainable intensification will increase our food security while shrinking the environmental footprint of agriculture. These strategies strive to maximize yields while simultaneously reducing detrimental environmental impacts. However, they must also be tailored to distinct climatic, ecological, political, and socioeconomic contexts.



Productivity

Increase production per unit of input such as labor, time, land, water, fertilizer, agrochemicals, seed, or feed.

Rural Prosperity

Preserve cultural value, reduce reliability on external inputs, improve economic stability and resilience, and convey the social and environmental values of rangelands, grazinglands, and croplands.

Environment

Assess the synergies and tradeoffs among ecosystem services, such as greenhouse gas emissions, soil health, biodiversity, and water quality and quantity, to provide producers and agencies with important information and new techniques for management and economic decision making.

LTAR Network Site	Year Established*	Major Agricultural Commodities
Archbold-University of Florida	1941	Beef cattle, citrus, forages, sugarcane
Central Mississippi River Basin	1971	Beef cattle, swine, corn, soybeans, wheat, forages
Central Plains Experimental Range	1937	Beef cattle, corn, wheat, forages
R. J. Cook Agronomy Farm	1999	Dairy cattle, small grains (wheat, barley), pulses, forages, oilseeds
Eastern Corn Belt	1974	Dairy cattle, poultry, swine, corn, soybeans, wheat, forages
Great Basin	1961	Beef cattle, dairy cattle, barley, forages
Gulf Atlantic Coastal Plain	1965	Beef cattle, poultry, corn, peanuts, cotton, vegetables, forages, biofuel feedstocks
Jornada Experimental Range	1912	Beef cattle, forages, cotton
Kellogg Biological Station	1951	Corn, soybean, wheat, forages, cellulosic biofuels
Lower Chesapeake Bay	1910	Dairy cattle, poultry, corn, soybeans, small grains (wheat, barley, rye), forages, vegetables
Lower Mississippi River Basin	1981	Catfish, poultry, corn, soybeans, wheat, rice, sugar cane, cotton
Northern Plains	1912	Beef cattle, sheep, small grains (wheat, barley, oats), corn, soybeans, pulses, forages, oilseeds
Platte River/ High Plains Aquifer	1912	Beef cattle, swine, corn, soybeans, wheat, forages
Southern Plains	1948	Beef cattle, small grains (wheat), forages, cotton
Texas Gulf	1937	Beef cattle, poultry, corn, cotton, small grains (wheat, oats), forages
Upper Chesapeake Bay	1968	Beef cattle, dairy cattle, poultry, corn, soybeans, small grains (wheat, barley, oats, rye), forages
Upper Mississippi River Basin	1992	Beef cattle, dairy cattle, swine, poultry, corn, soybeans, oats, forages
Walnut Gulch Experimental Watershed	1953	Beef cattle, forages

*All the sites were conducting research and collecting data before the LTAR network formed in 2012.

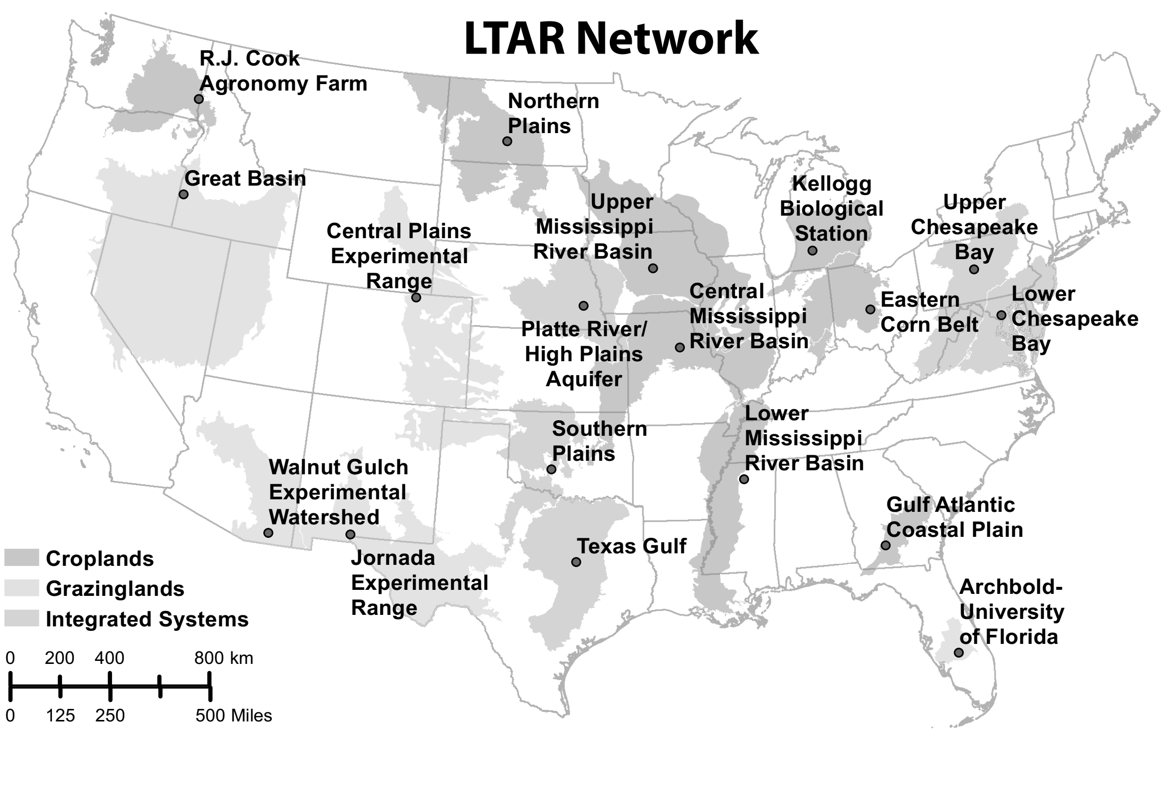
The Long-Term Agroecosystem Research Network

In pursuit of sustainable U.S. agriculture, the U.S. Department of Agriculture (USDA) launched the Long-Term Agroecosystem (LTAR) network. The LTAR network is composed of 18 locations distributed across the contiguous United States working together to address national and local agricultural priorities and advance the sustainable intensification of U.S. agriculture.

The LTAR network represents a range of major U.S. agroecosystems, including annual row cropping systems, grazinglands, and integrated systems representative of roughly 49 percent of cereal production, 30 percent of forage production, and 32 percent of livestock production in the United States. Furthermore, the LTAR sites span geographic and climatic gradients representing a variety of challenges and opportunities to U.S. agriculture.

The LTAR network uses experimentation and coordinated observations to develop a national roadmap for the sustainable intensification of agricultural production. While the LTAR network is a new network, experimentation and measurements began at some LTAR sites more than 100 years ago, while other locations started their research as recently as 19 years ago.

A primary goal of LTAR is to develop and to share science-based findings with producers and stakeholders. Tools, technologies, and management practices resulting from LTAR network science will be applied to the sustainable intensification of U.S. agriculture. Technical innovations, including new production techniques, genetics, and sensor infrastructure applied at the farm/ranch level can increase the capacity for adaptive management, reduce time and operational costs, and increase profits and the quality of life for producers.



LTAR Coordinated Research

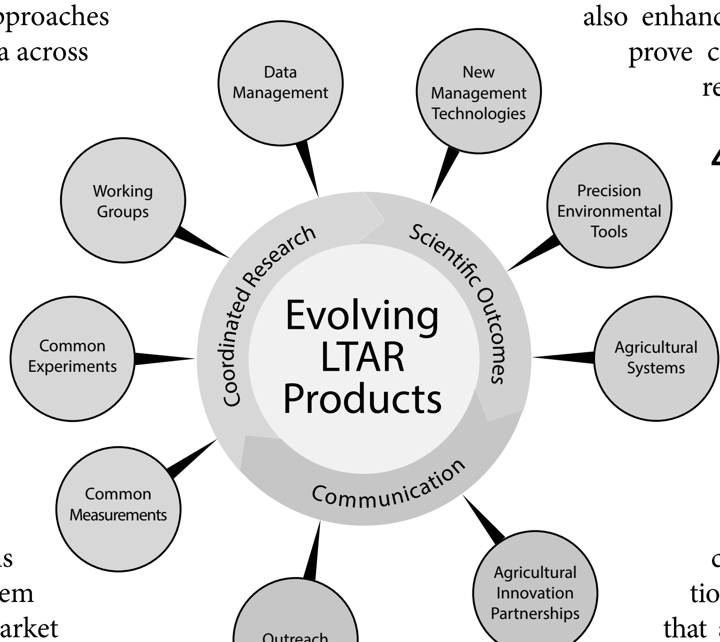
The LTAR network integrates question-driven research projects with common measurements on multiple agroecosystems (croplands, rangelands, and pasturelands) and develops new technologies to address agricultural challenges and opportunities. In addition, the LTAR network provides common measurements and data streams that complement other federally-funded national networks, such as the National Ecological Observatory Network (NEON) and the Long Term Ecological Research (LTER) network. The LTAR network features four linked approaches.

1. Coordinated Agroecosystem Research

Coordinating our research enables us to improve our understanding of how agroecosystems function at the field, regional, and national scales. Every network site has experiments with common goals and methods aiming to increase agricultural productivity and profitability while reducing negative environmental impacts, enhancing ecosystem services from agricultural landscapes, and improving opportunities for rural communities. Coordinated research allows scientists to develop and to test innovations across the United States, including new genetics, new production techniques, and sensor infrastructure.

2. Information Management

The LTAR network is committed to making its data open to researchers and the public. LTAR data managers and scientists are developing new approaches to organize and to integrate data across the LTAR network and partner sites. New data portals and visualization tools will accelerate scientific discoveries and bring real-time management technologies to producers' hand-held electronic devices.



3. New Management Technologies and Tools

Producers, landowners, policymakers, and the public want to make informed decisions about agricultural systems based on productivity, ecosystem services, off-site impacts, market conditions, rural prosperity, and future climate. Linking field monitoring, remote sensing, computer models, and web and mobile technologies provides scientists and producers with the tools to evaluate the multiple effects of agronomic practices and to manage the tradeoffs between production and non-production services. Site-specific decision support tools can also enhance adaptive management, improve conservation investments, and reduce producer overhead costs.

4. Agricultural Innovation Partnerships

Effective engagement with producers, industry, and other stakeholders increases the utility and adoption of information and technologies. The LTAR network includes social scientists in collaborative experiments to understand stakeholder needs and to incorporate new science information in practices and technologies that are adopted by producers and accepted by the public. Collaborations with industry promote the refinement and dissemination of technologies and expand markets for sustainably-produced agricultural products.

Group Type	Function
Measurement	Develop and implement methods to collect common measurements across the network
Information Management	Provide the computing and data management infrastructure necessary for network-wide research
Coordinated Research	Conduct question-driven research ranging from regional to network-wide scales
Agricultural Management Technologies	Develop new tools to improve agricultural productivity and environmental outcomes
Outreach and Communication	Develop strategies to disseminate network developments and engage with producers, policy makers, and stakeholders

LTAR Working Groups

Not all of the science needed for LTAR's success exists. The LTAR network uses network-level working groups to achieve research goals. Working groups are research incubators that coalesce around specific topics and agricultural challenges and opportunities. The groups develop or improve research methods, models, and tools. These groups also carry out coordinated, large-scale data collection and provide the infrastructure required to analyze and to disseminate these data.

Network-wide projects allow scientists from many disciplines to develop novel scientific insights at regional to national scales, evaluate whether and where these insights are applicable, and then adapt tools to local conditions. Working groups engage with stakeholders, producers, and industry in developing and disseminating these products.

Taking on the Big Challenges

Modern agriculture strives to provide food while maintaining other ecosystem services like clean air and water, biodiversity, and climate regulation. However, the increasing global population, greater demand for environmental stewardship, and changing climatic conditions require a concerted effort by all agricultural scientists to develop improved agricultural systems and strategies.

The newly-formed LTAR network is uniquely poised to address the local to global challenges facing agriculture. For example, the LTAR network examines the influence of agricultural practices on the water cycle so that water resources can be used in the most effective and efficient manner. At the same time, the network develops new strategies for preserving and increasing soil health and for using nutrient resources wisely. Combining this knowledge allows LTAR scientists to develop innovative cropping systems and to improve grazinglands management while actively maintaining agroecosystem health.

Conserving Water Resources

The circulation of water between the atmosphere, the soil, and the Earth's water bodies is described by the water cycle. These water pathways, which include precipitation, stream and river drainage, and evaporation, are often complex and affect the productivity and sustainability of agriculture. However, human activities including agriculture can also influence those pathways. In addition, some processes, such as evaporation and crop water use, are affected by temperature.

Understanding these processes is critical to ensure the sustainability of intensified agriculture in the future. LTAR network scientists will use data and information about these processes to help producers best utilize the precipitation they have now and will have in the future, while limiting soil loss and the transport of agricultural chemicals into streams, aquifers, and the atmosphere.

Measuring Water Resources

Measuring the components of the water cycle across the LTAR network provides insight about how water is used in a diverse range of agroecosystems. LTAR network scientists have installed instruments and advanced sensors throughout the network to measure precipitation and other meteorological conditions, surface runoff and water quality at multiple scales, and atmosphere-biosphere interactions using eddy flux towers. Data from eddy flux towers are used to calculate the amount of water and carbon that moves in and out of the atmosphere.

LTAR network scientists have also developed water budgets for all the sites, providing a baseline to understand how water pathways can shift as a result of management practices or varying climate. These also serve as templates for nutrient budgets (carbon, nitrogen, and phosphorus) at each site.

These data are used to develop more accurate methods and models to predict crop yields, to monitor crop stress due to increased temperature or excess soil wetness, and to inform irrigation decisions.

Maintaining Clean and Healthy Water

LTAR network scientists are evaluating water quality benefits associated with conservation practices using LTAR network data and data gathered by others. These projects include demonstrating the effectiveness of conservation systems that reduce soil erosion and contaminant transport and developing robust measurement strategies to improve predictions of contaminant movement.

For example, the time that groundwater remains underground before it enters surface waters affects how quickly land use and land management changes will influence components that affect stream water quality. LTAR network scientists have discovered a new way to measure this lag time and are conducting a network-wide experiment to understand how this lag time varies with watershed size and environmental parameters. In another network-wide project, LTAR network scientists are using advanced optical measurements to characterize dissolved organic matter (chemicals formed from decaying aquatic and terrestrial organisms and from anthropogenic sources) in surface waters. These network-wide experiments will help watershed managers develop conservation plans that minimize contaminant transport in the landscape.

Developing New Tools

LTAR scientists develop and use models to predict runoff, erosion, and contaminant inputs to waterways due to rain or snowmelt. These models, used by land managers and incorporated into apps for farmers and producers, include the Soil and Water Assessment Tool (SWAT), the Annualized Agricultural Non-Point Source Pollution Model (AnnAGNPS), the Kinematic Runoff and Erosion Model (KINEROS), the Automated Geospatial Watershed Assessment (AGWA, which provides a GIS interface to the KINEROS and SWAT), the Grassland Productivity Estimates tool (Grass-Cast), and the Snowmelt Runoff Model (SRM).

LTAR network scientists are also developing weather and climate tools to assist the LTAR community with their needs for historical and future weather data, seasonal forecasting, climate inputs to models, and documentation of historical and future trends in temperature, precipitation, and extreme events.

Remote sensing technologies ranging from Unmanned Aerial Vehicles (UAVs) to satellite-based sensors also provide model inputs and model validation data. Using these data streams, LTAR network scientists are developing fine-scale vegetation maps, daily maps of crop growth, and maps of evaporation and crop water use at sub-field scales. These improved maps are used to manage precision grazing in rangelands, to estimate crop yields, to understand how crop water use responds to management, to assess the impacts of irrigation strategies or a changing climate, and to provide early signals of crop stress caused by excessively dry or wet conditions.

Preserving Soil Health and Minimizing Soil Losses

Soils are critical elements of agroecosystems because they supply nutrients and water to crops and rangelands, and they recycle nutrients from animal manures and other nutrient-rich wastes. Well-managed, healthy soils ensure robust crop and forage production which contributes to the economic stability of rural communities. Soils also provide ecosystem services, such as regulating the water supply, cycling nutrients, maintaining biodiversity, and mediating greenhouse gases. However, soil losses due to water and wind erosion remove key components of the soil and reduce crop fertility. Keeping soil in the fields and on grazinglands also prevents the loss of nutrients and pesticides associated with the soil particles in field runoff from entering nearby surface water.

Monitoring Soil Health

Soil health and its resiliency refer to maintaining or improving the functions that soils serve in agroecosystems and the capacity of the soil to recover from disturbances like weather extremes and climatic changes. LTAR network scientists are examining soil microbial communities and their roles in successful crop production and are developing methods to predict soil health and its resiliency. Furthermore, integrating soil physical, biological, and chemical information with plant, atmosphere, and hydrologic data will provide a more complete picture of agroecosystem function and properties. Farmers, ranchers, and soil conservationists need this information about soil conditions to make the best agronomic decisions.

Carbon Cycle

Calculating the amount of carbon sequestered and released from agricultural lands is essential to developing a complete carbon budget. However, carbon budgets also require more robust technologies to analyze large areas. LTAR network scientists are carrying out studies using eddy flux tower measurements 1) to compare conventional corn-soybean rotation to a corn-soybean rotation with reduced tillage and a rye cover crop and 2) to conduct comparisons of grazing and land management strategies on carbon budgets in grazinglands. Results showed that soil carbon losses were greater under the conventional management systems. This comparative approach will be applied to conventional and aspirational agroecosystems at all LTAR sites.

Developing New Tools

LTAR network scientists have developed new models and tools to predict conditions that lead to erosion, so producers can reduce soil losses. The Rangeland Hydrology and Erosion Model (RHEM) is the first tool to predict hillslope erosion in rangelands based on changes in vegetation canopy and ground cover, and the Aeolian EROsion model (AERO) is a decision support tool for wind erosion assessment.

Producers employ a suite of conservation practices they can use to reduce erosion and to mitigate chemical transport. USDA in collaboration with conservation groups used watershed data to validate the online conservation toolbox Agricultural Conservation Planning Framework (ACPF), which has been designed for these stakeholders. The ACPF toolbox uses information about crop rotations, soils, and topography to identify sites where conservation practices, such as buffer strips, terraces, and wetlands, are best suited.

Using Nutrient Resources Effectively

Reducing nutrient losses from crop and livestock production is an important component of improving soil, water, and air quality across the United States and can play a role in improving economic performance of farms and ranches. However, the development of an effective nutrient management program for specific locations depends on many factors including soil type, topography, climate, and the types of cropping and livestock systems used. LTAR scientists carry out research on nutrient cycling and transport into and out of ecosystems. The results will help producers keep nutrients where they are needed and help land managers target areas where conservation practices will be most effective in mitigating nutrient losses.

Management Practices

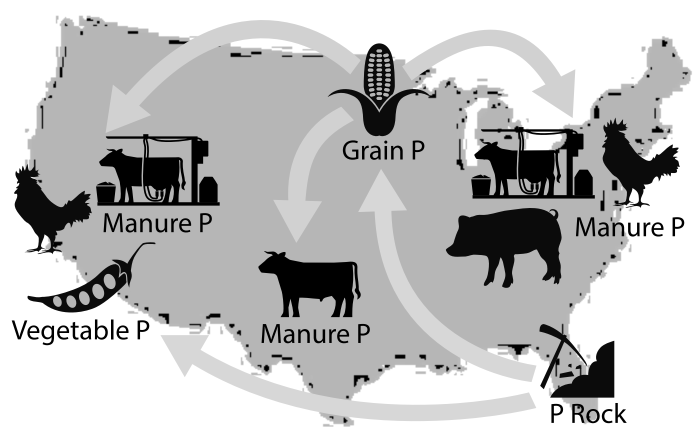
LTAR network scientists are developing and testing regionally-specific practices that allow producers to manage nutrients efficiently while maintaining production yields. For example, scientists have identified areas in the landscape (environmentally-sensitive areas poorly suited for crop production) where planting biofuel crops reduces nitrogen losses to surface waters while providing substantial feedstock biomass for biofuel production. Others showed that manure injection reduces ammonia volatilization, conserving crop-available nitrogen and reducing the need for supplemental fertilizers. LTAR network researchers are also addressing the integration of livestock and crops through the grazing of crop residues and cover crops. The resulting livestock manure serves as fertilizer, replacing synthetic fertilizer use.

Models and Tools

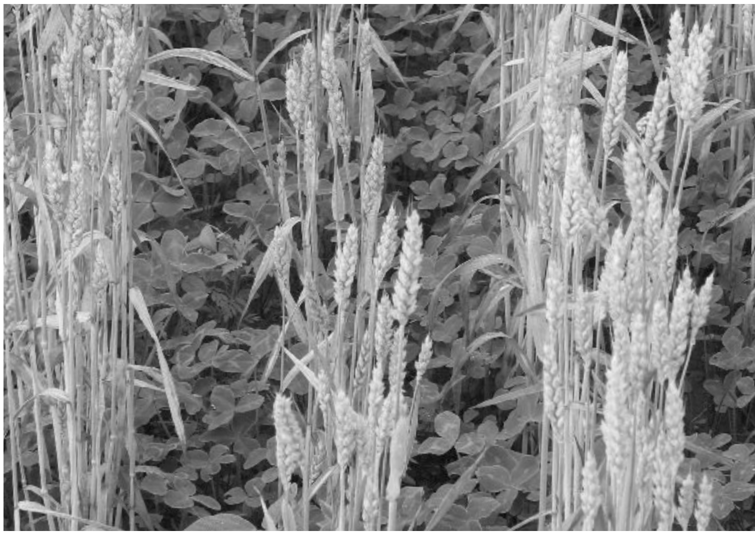
Producers are using computer software tools to guide site-specific decisions about timing and amounts of fertilizers and manure that can safely be applied and to target the most effective placement of conservation structures in the landscape. For example, the Annual Phosphorus Loss Estimator Tool, developed by USDA, is part of Wisconsin's nutrient management planning software called SnapPlus (Soil Nutrient Application Planner). The program helps farmers make the best use of their on-farm nutrients, as well as make informed and cost-effective commercial fertilizer purchases. In other work, LTAR network scientists used reflectance sensors and custom software to control variable-rate fertilizer applicators for improved nitrogen management. This approach has been shown to reduce the amount of nitrogen used and increase yields when compared to typical uniform application of fertilizer.

Manuresheds – Recoupling Crop and Livestock Agriculture

Over the last 100 years, U.S. farms have become increasingly specialized. Crops and livestock were previously grown together on the same farm, but now they typically exist as separate operations with much of the U.S. livestock raised or finished in confined areas. Animal feeding operations import feed from crop farms that can be geographically distant from the animals. Few mechanisms exist to return the unconsumed nutrients in the manure to areas to grow more feed. This decoupling of crop and livestock agriculture has contributed to the fragmentation of nutrient cycles and can result in the decreased water quality and quality of life for rural Americans living near feeding operations.



The case for Phosphorus (P) is shown here. LTAR network scientists are evaluating strategies to recouple agricultural systems through the sustainable reuse of manure nutrients using manuresheds (similar in concept to watersheds), which are the manure-spreadable croplands in the geographic, environmental, and social radius of one or more animal feeding operations. Working as a network allows LTAR scientists to identify viable solutions for closing fragmented nutrient cycles to improve productivity, environmental quality, and rural prosperity in locally appropriate ways.




Improving Cover Crop Performance

Cover crops provide numerous agroecosystem services. They can conserve and build soils, increase water and nutrient availability and use efficiency, and improve crop productivity and resilience. However, the effects of cover crops on these agroecosystem services are a function of the quality and quantity of their performance. Consequently, development of management practices and decision tools are needed.

Cover Crop Management

Cover crop performance depends on their genetics, climate, soil, and how they are managed (planting and termination method and timing). LTAR network scientists are quantifying these factors and defining optimal, region-specific strategies to maximize cover crop performance. This work includes breeding new cover crop germplasm, quantifying climate- and soil-specific performance, testing novel cover crop establishment equipment, and developing high-residue, no-till cash crop planting technology.

Cover Crop Flowers for the Bees

Flowering cover crops, such as sunflowers, can be beneficial to pollinators as well as the soil, and the flower size is important in attracting pollinators, but measuring the blossom size by hand can be imprecise and time-consuming. LTAR network scientists developed an image processing method to obtain more precise and objective measurements while reducing time and labor in the field. Producers can also use this method to estimate seed yields.

Cover Crop Tools for Farmers and Decision Makers

The effectiveness of a cover crop strategy is site-specific. LTAR network scientists are developing decision support tools to help farmers achieve their goals with cover crops. The Cover Crop Chart (Version 3, 2018) helps U.S. farmers select the most advantageous cover crops for their land with information on 66 cover crops and their benefits. LTAR network scientists have also developed the datasets used to construct the cover crop module in the Adapt-N decision tool, which is used by producers to make agronomic decisions on 1.5 million acres in 38 states. Lastly, scientists are creating a decision support platform that integrates a suite of decision support tools (species selection, seeding rates, economics, water, and nitrogen) that are national in scope but site-specific in recommendation.

Winter cover crops protect lands harvested in the fall and can sequester the nutrients not utilized by the previous crop, preventing the transport of those nutrients to surface waters. However, until now, evaluating how agronomic practices and climatic factors affect winter cover crop performance typically required individual field inspections. LTAR network scientists working with the Maryland Cover Crop Program (MCCP) used remotely-sensed data to develop a tool to evaluate cover crop performance across the state. This information was then used to ensure that conservation funds were spent based on performance. This tool is now being used operationally by MCCP throughout Maryland and can be adapted to other regions.

Managing Livestock and Pasturelands Sustainably

Livestock grazing is the most extensive land use in the United States, and grazinglands are greatly valued for the wealth of ecosystem services they provide. LTAR grazingland research reflects the diversity of U.S. grazinglands and the many approaches needed for effective management of a variety of systems, from the arid and semiarid lands of the Great Basin, Southwest, and Central and Southern Plains to more humid pastures in the Chesapeake Bay watershed and sub-tropical Florida. Opportunities for sustainable intensification of grazing production vary among these different regions, but an overarching objective is to inform decision-making about grazing management, including timing of grazing schedules, distribution and density of grazing animals, and the kind/class of animal.

LTAR network scientists are advancing precision technologies to understand and to predict livestock use in diverse landscapes. Ranchers and pasture graziers are integral to this research process. For instance, they are central participants in the Collaborative Adaptive Rangeland Management experiment in the Great Plains, which has been underway for nearly a decade, and in a study in the arid west comparing heritage and conventional cattle breeds at five working ranches and two feedyards.

In addition, LTAR network scientists are working to improve understanding of the interactions among socio-economic dynamics, environmental factors, and production practices in the grazinglands across the U.S. Current analyses include the evaluation of synergies and tradeoffs of adopting aspirational compared to conventional management. Overall, these network efforts are tailored to improve production, protect environmental quality, and maintain webs of social relations among livestock producers and rural communities in U.S. grazinglands, valued for the range of ecosystem services they provide in the United States and globally.

Maintaining Agroecosystem Health

Managing healthy agroecosystems means establishing and maintaining desired plant communities that are resilient to climate variability. This reduces sediment loss, improves water quality and quantity, and enhances stream flow that benefits wildlife habitat and biological diversity. Invasive species include non-native grasses as well as native trees and shrubs that have expanded their range. Unwanted plants can alter ecological and hydrological processes, reduce wildlife habitat, reduce productivity, affect human health, and have an enormous economic cost.

Invasive Species Management

Rangeland and cropping systems managers approach the threat of invasive species in multiple ways. The effective management of woody species is essential for the sustainability of 400 million acres of rangelands in the central and western United States. Brush management is one of the most cost-shared and implemented conservation practices on grazinglands. Its application can lead to increased forage, more protective plant cover, and less erosion. Fire is also used as a conservation practice in the management of grazinglands and can be an effective tool for restoration.

In croplands, invasive species and weeds are becoming increasingly resistant to traditional methods of control like herbicides. LTAR network scientists are working to develop different control strategies. One is example is using the Harrison Seed Destroyer (HSD), which connects to a combine and substantially reduces seed germinations by grinding the portion of the chaff that contains weed seeds.

Developing New Tools

Remote sensing-based tools and models allow scientists to examine the effects of brush management over large heterogeneous landscapes. The Rangeland Brush Estimation Toolbox (RaBET) is a geospatial tool that uses satellite imagery to assess changes in woody vegetation cover over space and time for large, mixed landscapes. RaBET provides maps of woody cover that can be used for planning and as input into models like RHEM.

LTAR scientists are using tower-mounted digital cameras called phenocams to make real-time on-the-ground measurements of the seasonal patterns in plant productivity (phenology). These observations are coupled with eddy flux tower carbon measurements to verify remotely-sensed data and to improve estimates of grazingland and cropland productivity. This work will enable land managers to evaluate agronomic changes on agroecosystem health and assess how phenological data can be inform and refine sustainable intensification strategies. In addition, LTAR scientists are exploring how plant diversity and plant traits are related to stability and resilience of productivity in relation to climate and management.

Looking Towards the Future of U.S. Agriculture

The charge placed on the LTAR network is to anticipate and to prepare for the future of U.S. agriculture. The LTAR network was created to develop the science that renders agriculture sustainable and satisfies the needs of a growing global population without diminishing the provision or quality of other ecosystem services, while enhancing rural prosperity and the health, well-being, and prosperity of people for generations to come.

Increasing the production of commodities in the United States requires strategies that reflect the diversity of U.S. agroecosystems. However, as policies, markets, and consumers change demands on U.S. agriculture, agricultural science must rise to the challenge. To achieve greater productivity, agriculture must therefore adopt an approach that includes a genetics, environment, and management (Genetics x Environment x Management x Social interactions) approach to understand and to overcome the constraints to productivity, which is at the core of the LTAR network mission.

For agriculture to achieve its potential to enhance the environment, LTAR is developing new strategies that can be applied at field, landscape, and regional scales, recognizing that some desired outcomes are easier to achieve than others. Efficient implementation of these strategies must target technology, management, and infrastructure to areas offering the greatest opportunities for greater productivity, new products and markets, and enhanced ecosystem services.

To support rural prosperity in the United States, agriculture must promote vibrant rural community institutions and economic infrastructures that provide equitable access to natural resources and reduce health risks to rural citizens. To accomplish this, LTAR also seeks partnerships with private industry that facilitate adoption of technologies and strategies where sustainable intensification of multiple ecosystem services is the shared goal.

The LTAR network looks forward to collaborating with other scientific institutions and networks (e.g., the U.S. Geological Survey, the National Oceanic and Atmospheric Administration, and the Natural Resources Conservation Service-Conservation Effects Assessment Project) to enhance interpretation of our findings. In addition, the LTAR network has and will continue to leverage additional funding from stakeholders and commodity groups to enhance research.

Ultimately, a balance of local and national concerns is expected to support effective strategies for sustainable intensification that reflect the broad diversity and national ambitions of the United States.

Long-Term Agroecosystem Research Network

For more information, visit LTARnetwork.org

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