

Impact Statement Catalogue

2014-Terminating Multistate Research Projects

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This catalogue contains all completed Impact Statements for multistate research projects that terminated in 2014. By summarizing and sharing the activities and outcomes of each multistate research project, Impact Statements show voters and leaders why supporting land-grant universities and sustaining the Agricultural Experiment Stations and Cooperative Extension is so important.

Impact Statements in this catalogue cover a wide variety of important topics: boosting swine, poultry, beef cattle, sheep, and sweet potato production; safeguarding bee health; managing plant parasites and invasive weeds; monitoring disease-carrying mosquitoes; tracking atmospheric deposition; making poultry, equine, and fisheries operations more sustainable; encouraging diet and exercise among older adults; improving subsurface drainage and microirrigation systems; and enhancing soil surveys, wetland soil management, and the use of solid wastes and wastewater on soils.



Want to know more?

Support for multistate research projects comes, in part, from USDA's National Institute of Food and Agriculture through the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1887) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. Additional funds are provided by contracts and grants to participating scientists.

These Impact Statements were prepared by the Impact Writer as part of the National Impact Writing Initiative of the Multistate Research Program. Coordination, editorial oversight, and physical space for the Impact Writing Initiative and the Impact Writer are provided by the Western Association of Agricultural Experiment Station Directors Office.

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How were these Impact Statements used?

Each of these Impact Statements was distributed to project participants, some of whom reported using the document at legislative meetings, presentations, and in trade publications. Impact Statements were also shared with NIFA leadership and communications teams. Impact Statements were also uploaded to databases and websites and repurposed in feature articles, news stories, and social media.



Photos courtesy of participating land-grant institutions and the USDA Photo Library. Icons by Freepik from www.flaticon.com.

Detection & Control of Swine Viral Diseases

NC-229 (2009-2014)

Devastating Respiratory Syndrome Difficult to Control

Porcine reproductive and respiratory syndrome (PRRS) is the most devastating swine disease in the U.S. PRRS jeopardizes foreign trade in breeding pigs, semen, and pork products, and upheaves the industry and farmers' livelihoods. Losses due to increased production costs, animal losses, and delayed marketability related to PRRS virus infection total around \$600 million each year.

Relatively few tools are available to producers and veterinarians for managing the disease. The virus can move efficiently between farms, even those that utilize rigorous biosecurity practices. The only currently available vaccine provides sub-optimal protection and, because the vaccine uses a live virus, it causes animals to shed the vaccine virus into the environment. It is also difficult for tests to distinguish vaccinated pigs from infected pigs. Because of limited vaccine efficacy, producers have tried to acclimate pigs to PRRS by intentionally infecting pigs with a live wild-type PRRS virus. This can result in continuous spread of PRRS and inadvertently spread other diseases.



PRRS virus is highly infectious and persistent, spreading every way possible (intrauterine, milk, feces, urine, saliva, semen, blood, and aerosol) and surviving a long time in cold, wet conditions. The virus mutates easily, making vaccine effectiveness inconsistent. It is also difficult to differentiate between field and vaccine strains. Photo by Scott Bauer/USDA-ARS.

Multistate Project Coordinates Research to Improve PRRS Control & Prevention

Formed in 2009, Multistate Research Project NC-229 brings together experts on swine production and viruses from 14 land-grant universities as well as international groups in China, Mexico, and Spain. As a multistate research project, NC-229's diverse group of scientists has the capacity to share resources, coordinate cutting edge research projects, divide and conquer specific problems, and respond quickly to new information and technology.

During the past five years, NC-229 researchers conducted studies to understand the epidemiology of PRRS and other emerging viral diseases of swine. Through these studies, they elucidated the mechanisms of host-pathogen interactions and identified virus reservoirs in the wild. Additionally, researchers studied the effect of virus strain variability on virulence and herd immunity. With this information, group members developed effective and efficient ways to detect, prevent, and control PRRS at all levels of swine production systems. These methods include vaccines, novel therapeutics, and selective breeding and host genome control, in addition to management and biosecurity strategies. The group also worked with producers to create a comprehensive swine health surveillance system. Scientists developed diagnostics capable of determining animal infection status, rapidly identifying virus strains, and differentiating animals exposed to field viruses versus vaccine viruses. In addition, they identified factors involved in farm-to-farm transmission, including the role of geography, the environment, and viral genetics. In collaboration with the National Pork Board and the American Association of Swine Veterinarians, the group developed outreach and educational materials and real-time delivery methods that provide essential biosecurity and compliance information.



Iowa State University photo.

Impacts

Swine producers and veterinarians have been able to rapidly apply NC-229's recommendations and guidelines in the field, improving animal health and reducing losses. For example, in University of Minnesota trials, farms significantly improved productivity after implementation of recommended air filtration technologies. In most cases, the pay-back period to cover initial investment in the system was between two and three years. Reduced disease incidence and stronger breeding herds and genetic stocks have improved and secured the supply of safe, affordable pork for consumers. By producing PRRS virus-free pigs and lowering the costs of PRRS, NC-229 has increased the competitiveness of U.S. swine industry. Swine disease surveillance and information provided by NC-229 has also been critical for maintaining and expanding markets.

Highlighted Research Findings & Impacts

PRRSV Pathology

- Clear definitions of the negative effects of PRRS virus on the pig immune system can be used to design better cross-protective vaccines.
- Better understanding of the factors at play during severe infections versus less severe infections helps scientists develop more suitable vaccines and vaccination strategies.
- Kansas State University researchers identified effects of PRRS virus infection on digestibility. This information was used to formulate diets that optimize growth during PRRS infection.

Transmission

- NC-229 provided producers and veterinarians with knowledge and tools to improve air filtration and reduce airborne transmission of PRRS virus between farms.
- University of Minnesota researchers identified aerosols and hand contact surfaces as possible routes of influenza virus exposure to people on commercial farms, live animal markets, and agricultural fairs.
- University of Illinois researchers revealed multiple PRRS virus introductions from Canada to the U.S., which are causing a major shift in virus genetic composition in the Midwest. These insights into virus evolution will facilitate targeted programs for control and prevention.

Diagnostics & Monitoring

- Iowa State University led development of a new method using saliva to detect PRRS virus and antibodies. Saliva samples are an economical and rapid alternative to invasive blood samples for disease surveillance.
- NC-229 developed the Luminex testing system, which has higher sensitivity and specificity. Luminex is becoming popular because it is available at a low cost and can be used on a single small-volume sample, including non-serum samples, such as oral fluids and meat juice.
- South Dakota State University developed a less time-consuming, more affordable method for assessing the presence of Porcine Epidemic Diarrhea Virus.
- New, cost-effective methods helped track infection and determined whether eradication programs should be implemented on individual farms or entire regions.

Treatments

- Researchers found that PPMOs inhibited PRRS virus replication, protected against cell death, and resulted in lower presence of the virus in the bloodstream and fewer lung lesions in infected piglets.
- Newly discovered genes that possess potent anti-PRRS virus properties can be incorporated into vaccines and other antiviral therapies.
- Better understanding of genetic variation in PRRS viruses is guiding development of new vaccines with broad efficacy.
- University of Minnesota researchers found that electromagnetic particle ionization reduced airborne PRRS and influenza viruses.
- Ohio State University researchers discovered that intranasal delivery of an inactivated PRRS virus vaccine may elicit anti-PRRS virus immune response and clear the virus from the bloodstream.
- NC-229 scientists informed stakeholders of age-dependent differences in the ability of pigs to resist PRRS virus infection, encouraging farmers to apply vaccines at the right time.

Genetics & Breeding

- NC-229 helped verify important genotypes and phenotypes that predict resistance/susceptibility to PRRS virus infection.
- NC-229 researchers at Kansas State University identified genomic markers for improved response to PRRS virus, creating the opportunity to conduct marker-assisted selective breeding.
- Researchers identified DNA markers associated with Porcine Circovirus Associated Disease. Breeding selection based on DNA markers can be an alternative to vaccination for disease control.

Want to know more?

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 - University of Nebraska, Lincoln
 - North Dakota State University
 - Ohio State University
 - Purdue University
 - South Dakota State University
 - Virginia Polytechnic Institute and State University
 - University of Wisconsin
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 - USDA-ARS Beltsville Agricultural Research Center
 - USDA-ARS National Animal Disease Center
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Impact Statement compiled by Sara Delheimer.

Sustainable Solutions to Problems Affecting Bee Health

NC-1173 (2009-2014)

Honey Bee Colonies Facing Serious Issues & Declines



The black bump on the back of this honey bee is a varroa mite parasite, which sucks vital fluids and can transmit viruses and pathogens to the bee. ARS photo.

Honey bees provide essential pollination for US crops, adding over \$15 billion to annual crop value. Demand for honey bee colonies is skyrocketing—each year, growers supplement wild bee pollination by renting more than two million managed honey bee colonies—but catastrophic die-offs are threatening the supply of healthy colonies and the production of many nut, berry, fruit, vegetable, and seed crops.

Parasitic mites, exposure to pathogens and pesticide chemicals, and environmental conditions have contributed to the wide-scale decline of bees. In addition, a new disorder called Colony Collapse Disorder (CCD) has destroyed one-third of all honey bee colonies in the US every winter since 2006. CCD may be caused by new pesticides and pesticide use patterns, nutritional deficits associated with monocultures, loss of immunity to pathogens, or new exotic pathogens. Lack of viable, industry-wide honey bee breeding programs has made these losses even more profound, and piecemeal research has made it difficult to manage these challenges on a broad scale.

Multistate Project Forms to Develop Sustainable Bee Management Strategies

To coordinate and conduct wide-scale research on the causes of recent honey bee decline in the US, Multistate Research Project NC-1173 formed in 2009 and brought together experts in honey bee nutrition, genomics, breeding, parasitology, pathology, toxicology, and general ecology. Participating Extension professionals shared technology and information with beekeepers, farmers, and other stakeholders through new, updated websites, technical and trade magazines, and Master Beekeeper and Bee College programs.

Researchers surveyed fields and bee colonies for environmental contaminants and observed the effects of different levels on bee health. Screening hundreds of pollen samples from rural, urban, and suburban honey bee hives for pesticide residue, researchers traced the movement of pesticides into blueberry, cranberry, and summer squash flowers. Researchers also conducted studies to determine the effective dosage of eight miticides and to test how the compounds in these miticides affect bee health, particularly sperm counts and viability among worker bees and the mortality of queen bees. NC-1173 members in Indiana initiated a regional cooperative to share mite-resistant bee breeding stocks. To address diseases, researchers monitored pathogen type and prevalence in commercially managed honey bee colonies. Researchers also compared gene expression in infected and uninfected bees, identifying specific genes related to immune response and disease resistance.

Other studies looked at environmental factors, like nutrition. In one series of tests, scientists inoculated worker bees with fungal pathogen spores and observed their longevity when fed diets of mixed-bee pollen, monocultural pollen, or no pollen. A similar project recorded the impacts of normal, optimal artificial, and suboptimal diets on bees' response to pathogens.

Ecologists identified land and farm management practices associated with high levels of native bee pollination. Native bees (non-*Apis* species, or any bee other than a honey bee that is endemic to North America) do not produce honey, but are better pollinators of some plants, especially tomato, eggplant, blueberries, and pumpkins. Researchers also surveyed microbes among commercially-produced and wild non-*Apis* bees. Other studies showed no significant effects of pesticides on the behavior and health of non-*Apis* bees.



Honey bees extract pollen from many kinds of flowers. Photo by Bob Peterson, Flickr (CC BY 2.0).



Native bees, like the southeastern blueberry bee, are efficient foragers. Each bee is capable of visiting as many as 50,000 blueberry flowers in its short life, pollinating enough of them to produce more than 6,000 ripe blueberries, which are worth \$20 or more at market. USDA illustration.

Increased Knowledge & Adoption of Best Practices

- Beekeepers following NC-1173 recommendations have saved an estimated 10,500 honey bee colonies, valued over \$5,750,000 annually.
- NC-1173 efforts have increased the number of beekeepers in many states and attracted dozens of large- and small-scale commercial beekeepers to provide pollination services to crop growers.
- North Carolina Master Beekeeping Program membership has jumped to over 6,400. Active members have provided thousands of hours of volunteer time and services, saving taxpayers an estimated \$5.6 million in extension-related activities since 2003.
- Since the inception of the Master Beekeeper Program in Florida, 70 participants have achieved “Advanced Beekeeper” status, and 26 have achieved “Master Beekeeper” status, by earning public service credits for starting observation hives, giving presentations, and performing other outreach activities. By the end of September 2012, over 921 public service credit activities had reached almost three million people.
- The Bee College program in Florida has increased beekeeper knowledge according to surveys of participants. All surveyed beekeepers said they would use what they learned in their own operations, and all non-beekeepers said they would become beekeepers as a result of attending the Bee College.
- In Connecticut and Tennessee, Beemaster Program participants improved average knowledge 33.6% according to pre- and post-test scores.
- In 2012, use of the “Bee Health” eXtension website in Tennessee increased 17.4%. YouTube channel subscribers increased 49.4%, and YouTube video views increased 54%.
- The Texas Beekeepers Association, in collaboration with the Texas Apiary Inspection Service and Texas A&M University, has adopted a new Texas Master Beekeeper Program.

Reduced Losses to Parasites & Diseases

- NC-1173 helped edit the Honey Bee Coalition’s Tools for Varroa Management guidebook. This guide explains practical, effective methods that beekeepers can use to measure varroa mite infestations in their hives and select appropriate control methods. Effective mite control will reduce colony losses and avoid potential spread of infectious disease among colonies.
- Beekeeping research and extension programs in Tennessee have helped beekeepers reduce colony losses to parasitic mites and other causes by 15%.
- NC-1173 genetic research has facilitated the development of honey bee stocks and breeding programs that incorporate valuable resistance traits. Multistate coordination has provided a broader population base for selective breeding, so that multiple resistance traits can be incorporated to decrease loss of hives from varroa mites.
- Artificially inseminated queen honey bees with resistance to varroa mites are being used as breeders in at least a dozen states, helping to propagate healthy local hives.
- Increased knowledge of pathogen identities and levels within bee hives, as well as honey bee antimicrobial and antiviral defense mechanisms, has made it easier to design and implement targeted, effective control strategies that can save bee colonies.

Reduced Pesticide Exposure

- NC-1173 has led scientists, regulators, government officials, and industry representatives to standardize risk assessment measures for pesticides and change some pesticide registrations.
- Toxicology methodologies developed by NC-1173 are being used by state, national, and international agencies to evaluate pesticide use.
- Results from NC-1173 projects are being used by beekeeping organizations and the Environmental Protection Agency to decide how pesticide regulations, formulations, and application methods can be changed to protect honey bees.
- NC-1173 members in Connecticut provided guidance on insecticide use during bloom in almonds to protect immature honey bees from exposure to developmental toxins.
- Ohio beekeepers were provided with a research-based guide for avoiding harmful synergistic interactions when honey bees are exposed to more than one miticide and when miticides interact with fungicides applied to orchard crops.

Increased Use of Wild Bees

- Pumpkin growers in New York can reduce or even eliminate costs associated with pollination services from managed honey bee colonies by relying exclusively on wild non-*Apis* bees and wild *A. mellifera*.

Changed Planting Practices to Protect Bees

- NC-1173 Extension efforts in the Midwest are changing corn planting methods, encouraging farmers to use talc in the planting box to minimize bee exposure to insecticidal seed treatments.



Biosciences technician at the ARS Bee Research Laboratory, Nathan Rice, uses a honey rake to remove beeswax that seals honeycomb cells full of honey. ARS photo.

Want to know more?

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preview.extension.org/bee%20health

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This Impact Summary was compiled and designed by Sara Delheimer.

Controlling Poultry Respiratory Diseases

NC-1180 (2009-2014)

Poultry Production and Consumption Threatened by Respiratory Diseases



Photo by Scott Bauer, USDA.

The U.S. is the world's largest producer and second largest exporter of poultry meat. In the U.S., poultry meat and egg production has been continually increasing, and consumption has surpassed all other meats. Surveys show that consumers prefer chicken over beef and pork in terms of taste, versatility, ease of preparation, nutrition value, consistency of quality, and price. In 2007, the combined value of production from broiler chickens, eggs, turkeys, and chicken sales was \$31.9 billion; however, the efficiency and competitiveness of the poultry industry is seriously threatened by respiratory diseases. These include infections caused by laryngotracheitis, bronchitis, and lentogenic Newcastle disease viruses, *E. coli* and other bacteria, and fungi. Infection often results in poor performance (e.g., decreased growth) and high medication costs, racking up huge losses for producers. Condemnation at processing and strict export restrictions add to these losses, impacting the industry and economy nationwide. Some respiratory disease agents are also classified as agrobioterrorism agents requiring modified biosecurity measures. In order to protect the nation's food supply and the economic well-being of farmers and the poultry industry, more research is needed to develop rapid diagnosis and control of major respiratory diseases.

Multistate Research Project Improves Diagnostic Tools and Control Strategies

In 2009, Multistate Research Project NC-1180 formed to develop effective long-term strategies to control poultry respiratory diseases. The multistate approach has generated solutions that are practical for diverse poultry systems and specific pathogens impacting farms across the U.S. During the past five years, researchers identified reservoirs of infectious agents in wild birds and factors involved in transmission to commercial poultry. Researchers also improved diagnostic capabilities, including multiple real-time and rapid on-farm tests to detect infection status and identify specific disease strains. Scientists also collected samples and characterized emerging respiratory disease agents. To develop vaccine candidates, scientists identified key genes and antigens associated with protective immune response.



Photo by Stephen Ausmus, USDA.

Research and Extension Help Poultry Industry Remain Competitive and Profitable

Building on study results, NC-1180 developed new strategies for managing poultry respiratory diseases. Faster, more accurate diagnosis and more effective control options, including vaccines, have reduced poultry deaths, sickness, and condemnation. This has enabled the poultry industry to remain competitive and profitable. In turn, consumers continue to enjoy safe, healthy, and affordable poultry meat and eggs. In addition, new vaccines and refined biosecurity practices have reduced the risk of these diseases spreading to humans.

Reducing Risk of Transmission

- Wild birds are a reservoir of avian influenza and other viruses, and some species may serve as intermediate hosts. For example, ducks infected with highly virulent strains of avian influenza viruses shed the virus for long periods of time, perpetuating the virus in the environment and increasing the possibility of transmission to commercial poultry. Researchers have suggested ways to eliminate viruses in the environment, including disinfecting poultry houses,



Photo by Keith Weller, USDA.

composting litter for three days, improving beetle and rodent control, and treating drinking water with commercial biofilm removers. These practices have reduced the incidence and severity of outbreaks on many farms.

- Researchers discovered that some viruses can replicate in the reproductive tract, which means the viruses can be sexually transmitted and can be found in or on eggs. In hens artificially inseminated with semen containing infectious bronchitis virus, egg internal and external quality was negatively affected. Researchers also detected low pathogenic influenza viruses inside the eggs of infected turkeys. Following these findings, researchers suggested better practices for egg handling and movement to reduce transmission through contaminated cracked eggs and egg flats.

New Vaccines and Vaccine Practices

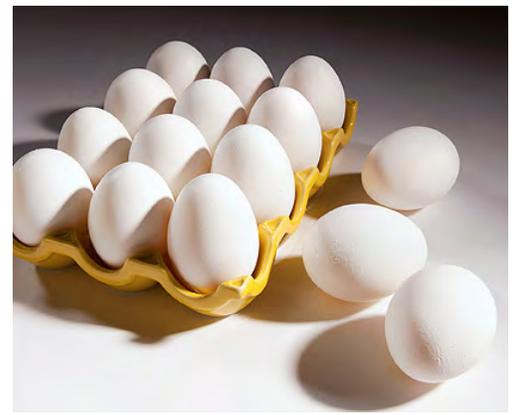
- Researchers developed a plant-based vaccine for avian influenza. This type of vaccine can be easily fed to poultry. This vaccine has promising potential for poorer countries, which are a major source of poultry influenza infections, but lack access to high-tech vaccination tools. Newcastle disease virus vaccine candidates developed by NC-1180 researchers are being evaluated by a vaccine company for distribution worldwide. In addition to providing immunization against Newcastle disease, these new vaccines decrease the amount of virus shed into the environment by vaccinated birds. Other studies demonstrated that chicken interferon is biologically active against the pandemic H1N1 avian influenza virus, making it a possible treatment.
- Researchers also identified vaccination practices that reduce the risk of transmission through decreased shedding. For example, recombinant laryngotracheitis vaccines do not prevent virus shedding, whereas chicken embryo origin vaccines provide significant protection against shedding. Other studies showed that in-ovo vaccinations are much safer than the live vaccines currently used against infectious bronchitis. Scientists also noted that reducing the number and diversity of live virus vaccines given at the same time as laryngotracheitis vaccines may optimize protection against laryngotracheitis.

Rapid Diagnostics

- NC-1180's genomic sequence data for viruses has led to improved diagnostic tests. Researchers developed a new test for laryngotracheitis and avian influenza viruses. This test is faster, more sensitive, and cost effective because it does not require sophisticated equipment. With the new test, researchers can quantify the viral load of laryngotracheitis in chickens, providing valuable data for estimating transmission and control. A tool to rapidly identify *M. gallisepticum* infection without the use of expensive technology was also developed. In addition, scientists developed an influenza screening tool that can be used in vitro, reducing the use of live animals and research costs. The group also created a tool to rapidly identify multiple avian influenza types in the same sample. This tool can identify infected flocks in large populations of vaccinated poultry. The National Animal Health Laboratory Network adopted two tests developed by NC-1180 that allow real-time differentiation between North American and pandemic H1N1 influenza viruses.

Emerging Risks

- NC-1180's continued monitoring of infectious pathogens in commercial poultry is important for evaluating the effectiveness of vaccination programs. Close monitoring also helps isolate and characterize field pathogens that break through immunization, giving scientists and farmers a chance to prevent serious, costly outbreaks. Furthermore, more sensitive diagnostic tests ensure that the circulating viruses are properly identified.



NC-1180 identified practices for inactivating Newcastle disease and avian influenza viruses in eggs. Photo by Peggy Greb, USDA.



NC-1180 member Dr. Chang-Won Lee tests the virulence of particular virus strains, how they interact with other pathogens, and how they respond to various vaccines. Photo by Ken Chamberlain, Ohio State University Marketing & Communications.

Want to know more?

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University of Minnesota
Ohio State University
Purdue University
Southeast Poultry Research Laboratory
USDA-ARS, Georgia

Impact Statement compiled by Sara Delheimer.



Committee on Swine Nutrition

This project fostered swine nutrition research, enabling profitable swine production systems that provide high-quality pork to consumers worldwide.

Who cares and why?

The U.S. is the world's third-largest producer and consumer and largest exporter of pork. Maintaining or improving the competitiveness of U.S. pork in the global market is a high priority, and pork consumption is expected to continue to increase in the U.S. However, pork production increases have varied substantially by region over the past years, largely due to changes in state environmental policies and shifts in available feedstuffs. Environmental policies are more concerned about levels of phosphorus in manure that may pollute surrounding land and water. Pork producers are also confronted with rising feed costs, which already account for 70% of the total cost of pork production. Corn and soybean meal have been the main staples of swine diets since the 1950's, but large quantities of cereal grains are now used for ethanol production, raising prices and limiting the supply available to swine farmers. While the byproducts of ethanol production can be used as feed, farmers are concerned that this feed may result in poor pork quality. Pork producers are also concerned about corn contaminated with vomitoxin and other mycotoxins, which reduce feed consumption and pig growth. In light of these challenges, swine nutrition research is needed in order to develop new technologies and practices to improve the economic and environmental sustainability of swine production across the U.S.



What has the project done so far?

Since 1964, the Multistate Committee on Swine Nutrition has conducted timely, robust research addressing concerns about swine nutrition. Over the past five years, NCCC-42 researchers have completed studies on dietary fat sources and levels for weanling pigs, digestibility of different feedstuffs, nutrient levels in excretions, vomitoxin effects, and belly firmness and poor carcass quality due to high levels of distillers dried grains (made from the byproducts of ethanol production) in feeds. Based on this work, the committee has determined the best uses for different feedstuffs and identified processing methods that improve feed quality. In addition, research has identified a product that can eliminate negative responses to vomitoxin-contaminated corn and has demonstrated that swine diets containing up to 45% distillers dried grains do not affect swine performance. The group has also formulated diets that minimize phosphorus and calcium levels, so that less

Corn and soybean meal have been main staples of swine diets since the 1950s; however, due to limited availability and rising feed costs, farmers are exploring alternative feedstuffs. NCCC-42 is helping farmers find options that still meet the nutritional requirements of pigs throughout their lives. Photos by Dr. Marcia Shannon, University of Missouri.

is excreted into the environment. Because these studies have been coordinated across states and have pooled data from numerous animals, researchers have been able to draw valid conclusions and establish nutritional recommendations. For example, the group has established nutritional requirements for vitamins, minerals, and amino acids. Research conducted and published by the NCCC-42 committee was cited more than 20 times in 6 different chapters of the 2012 Nutrient Requirements of Swine.

Impact Statements

NCCC-42 has enabled the U.S. pork industry to adapt and prosper. Specifically, the project's efforts have:

Reduced costs for farmers and prevented pork prices from rising for consumers by recommending diets that improved pigs' rate of weight gain and feed efficiency.

Improved pig health and lowered piglet mortality by recommending more nutritious diets.

Enhanced pork quality, helping swine farmers meet consumer demands. For example, today's pork has 16% less fat and 27% less saturated fat than in 1991.

Evaluated different feedstuffs, providing producers with options that minimize their costs but do not reduce pork quality.

Prevented phosphorus pollution in the environment by providing research that will reduce the concentration of phosphorus in swine manure.



NCCC-42's research has shed light on how to efficiently and nutritiously feed grow-finish pigs, so that the pigs achieve optimum weight gain and meat quality. Other NCCC-42 studies have focused on making sure that pig feeding practices are environmentally sound. Photo by Dr. Marcia Shannon, University of Missouri.

What research is needed?

Further research is needed to continue to refine the nutrient requirements of lean, fast growing pigs. In particular, researchers need to more clearly establish the phosphorus requirements of swine during various stages of growth. Researchers must also continue to evaluate new feed ingredients that can be used in starter feeds for young pigs and in grower-finisher diets for swine and assess feeding schemes that allow large amounts of grain co-products such as distillers dried grains in diets.

Want to know more?

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This project was supported by the Multistate Research Fund (MRF) established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1888) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. For more information, visit <http://ncra.info/>.

Written and designed by Sara Delheimer

Soil Surveys & Interpretation

NCERA-003 (2009-2014)

The Importance of Soil Surveys

Most life on Earth depends on soil—the layers of organic matter and minerals along the planet’s surface that provide a nutrient-rich medium for plant growth, water storage and purification, and a habitat for decomposers. Because of the important roles soil plays, and because soil is incredibly reactive to human disturbances, soil survey information is necessary for land and natural resource management at all scales. Many local and global environmental concerns, such as erosion, crop productivity, sustainability, biodiversity, and climate change, are intricately linked to soil quality and processes. To address these issues, soil survey information must be robust, reliable, and useful to a broad range of users—especially those who may have limited knowledge about soils and soil science. Useful soil survey information requires skilled scientists and modern technology to collect and interpret the data. However, numbers of soil scientists and resources have declined recently. Furthermore, as a relatively new field, soil science often shifts focus, making coordination and communication even more essential so that scientists can stay on top of priority issues and best practices.



Updating soil survey information for eroded fields during and after restoration is important. In the bottom photo, an NCERA-003 scientist stands in a deep soil erosion gully in a soybean field and prepares to measure it with a soil auger.

Multistate Committee Forms to Coordinate and Improve Soil Surveys

Multistate Research and Extension Committee NCERA-003 guides the collection and interpretation of soil survey information. Drawing on the diverse expertise of scientists from universities across the U.S., the group is uniquely qualified to weigh in on national priorities and refine national directives to suit specific regional needs. Along with their individual teaching, extension, and research responsibilities, members work together to provide essential coordination and support for organizations, such as the National Cooperative Soil Survey (NCSS, an organization of federal, state, and local agencies and partners with a public mandate for inventory, use, and management of soil resources) and the Natural Resources Conservation Service (NRCS). For these organizations, NCERA-003 members identify research and education needs, coordinate soil survey research and design, and evaluate soil survey practices and tools. NCERA-003 members also provide scientific and technical expertise for developing improved systems for storing, retrieving, analyzing, and disseminating soil survey information.

Committee’s Research and Guidance Has Had Multifaceted Impacts

CHANGING & IMPROVING SOIL SCIENCE

By identifying research gaps, developing new research methods, and encouraging multidisciplinary research, NCERA-003 has **broadened the scope and resolution/scale of soil science research**. Multidisciplinary research at a wider variety of scales has led to **improved soil sampling and modeling that better represent a wider range of soil characteristics and processes**. The committee’s coordination has also fostered more cooperative research projects, **minimizing duplicative studies and activities and using important time, money, and labor resources more efficiently**. The group’s work has also **increased awareness of the importance of soil science**. Members of the committee have **trained the next generation of soil scientists, ensuring that they have a wider range of skills and perspectives than their predecessors so that they can meet society’s needs**. In particular, the group directed new NRCS approaches for training employees in field soil survey techniques and soil judging.

INCREASING KNOWLEDGE

Outreach efforts have **improved understanding among key soil survey information users and decision-makers**, particularly about the relevance of soil survey scale and resolution and the importance of the soil resource and its interactions with landscape processes, water, and living organisms.

EASING ACCESS TO MORE RELIABLE, USEFUL DATA

NCERA-003 has modernized and organized the Soil Survey Information database, **easing access to more robust and reliable data, helping users make smart land use decisions in a timely manner**. For example, NCERA-003 combined soil survey information, so that one data set can be used in many different ways and easily transferred between different computer systems and applications. The

committee has also made databases more robust, adding thousands of new soil profiles and associated soil characterization data to the USDA National Soil Survey Lab's (NSSL) Soil Characterization database and incorporating Agricultural Experiment Station and university data into the National Soil Survey database, so that **users can access the specific information they need to manage their land**. The team has also addressed technical problems before data are entered and **reduced concerns about the integrity of data**.

INFLUENCING LEGISLATION

As a committee with diverse expertise, NCERA-003 has collectively **influenced a wide range of legislation and policies**, and members have even provided expert witness testimony in hearings and lawsuits. For example:

- NCERA-003 findings and recommendations, including the need to update the soil survey after every levee breach and subsequent flooding event, were presented during testimony by Ken Olson at the Mississippi River Commission/U.S. Army Corps of Engineers hearing in New Madrid, MO, on March 23, 2015.
- NCERA-003 members have screened soil damage analyses as part of a federal lawsuit brought by 140 New Madrid floodway farmers over the extent and cost of soil damage as a result of floodway use.
- Discussions with NCERA-003 members have prompted the NRCS to shift research focus to include rapid carbon assessment, salinity, soil quality, and laboratory soil carbon analyses.
- As a result of the NCERA-003 committee's persistent work, the NRCS has changed both the approach and the documentation of eroded soils in the NCSS program.
- NCERA-003 convinced the NRCS to reopen negotiations with the USGS to cooperate in a national geochemical landscape initiative that will provide in-depth soil information.

ADDRESSING ENVIRONMENTAL PROBLEMS

The efforts of NCERA-003 have **given the field of soil science a better position and resources to effectively address environmental concerns**. For example, NCERA-003 has offered valuable advocacy and guidance that has **influenced remediation approaches and levee management decisions in areas affected by flooding**. Data collected by the group has been used to support crop yield and biomass estimates and has **improved models that better predict yield within the context of changing climate**. These crop yield and biomass data have also been useful in **identifying suitable soils for bioenergy production**. Many states and counties also used crop yield and biomass estimates to inform accurate land appraisals and assessments.

Want to know more?

NCERA-003 was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1888) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. For more information, visit <http://ncra.info/>.

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This Impact Summary was compiled and designed by Sara Delheimer.

Papers & Presentations

- Members have issued publications, reports, and *Soil Horizons* articles.
- The group's first soil carbon sequestration paper, published in *Soil Science Society of American Journal* was downloaded 3,500 times in 11 months (most papers gets 153 downloads in a life time).
- The group's second soil carbon sequestration paper, published in the *Journal of Soil and Water Conservation*, was the 7th most downloaded for four months straight.
- NCERA-003 members delivered an influential presentation on classification of human-impacted soils at 18th World Congress of Soil Science that prodded other countries to include human-impacted/eroded soils in their classification systems.
- As a result of active support by NCERA-003 members and NRCS cooperation, the Smithsonian Soils Exhibit opened in 2008 for 18 months with specific information on the benefits of soil survey information. This exhibit introduced the field of soil science to over 1 million visitors each year.
- Workshops, training sessions, courses, and online training sessions have been conducted for students (including K-12).
- The committee sponsored and co-organized the Soil Carbon and Greenhouse Gas Dynamics in Agricultural Land symposium. The symposium gave policymakers the information they needed to develop a soil carbon cap and trade credit program.



Corn roots in healthy soil. Photo by Ron Nichols/NRCS.

Increased Efficiency of Sheep Production

NCERA-214 (2009-2014)

Sheep Industry Faces Many Challenges, but Shows Promise



Problems with fertility related to improper breed selection or body conditioning or a short lambing season contribute to inefficient sheep production. Photo by Natasha Pettifor, Cornell University.

Sheep production is an important part of American agriculture. More than 80,000 farmers and ranchers raise sheep in the U.S. Each year, these producers sell over \$760 million worth of products from over five million sheep. Although per capita consumption of lamb is low relative to beef, pork, and chicken in the U.S., growing markets for sheep products—especially among recent immigrant populations—are promising, and the American Lamb Board is finding new ways to promote lamb in traditional markets. A wide array of breeds, relatively strong recent lamb prices, and millions of acres of potential pasture make the sheep industry able to adapt to market conditions, producer needs, and consumption trends, such as rising demand for cheese and yogurt made from sheep milk. However, the industry is still struggling with animal health concerns, economic issues, and global competitiveness. Gastrointestinal parasites, predators, and diseases can affect product quality and safety and require costly prevention and treatment methods to control. Of the 154 million pounds of lamb and mutton produced by U.S.

farmers in a typical year, just over nine million pounds are exported to other countries. To overcome production challenges, farmers and ranchers need new knowledge and technology that will improve efficiency, sustainability, profitability, and competitiveness in the worldwide market.

Committee Forms to Facilitate Research & Extension

Formed in 1999, multistate research and extension project NCERA-214 uses a collaborative approach to deal with the wide scope of challenges facing the sheep industry and to generate sustainable solutions that can be applied effectively industry-wide. Collaboration enables researchers to exchange limited resources, including information, research animals, and genetic material, among different institutions and use common research approaches, allowing comparisons among studies. With scientists trained in genetics, reproduction, nutrition, meats, management, and animal health, the NCERA-214 committee is uniquely suited to develop integrated animal management and animal health and well-being systems that support efficient, competitive, and sustainable production of safe, wholesome products.

Multistate Project Guides Sheep Industry Toward Sustainability



Photo by University of Wisconsin-Madison, College of Agricultural and Life Sciences.

Research results from this committee benefit sheep producers and consumers by cutting production costs, improving animal productivity, and increasing product quality. Extension programs and workshops have been incredibly successful in raising awareness and knowledge among producers, with participating producers reporting changing their practices and increasing production efficiency.

More specifically, research results have provided breed resources, genetic information, and guidelines that help the sheep industry use the most appropriate breeds in crossbreeding programs. With more breeds available and better information about breed performance, sheep producers have been able to improve reproductive efficiency and produce more nutritious, leaner lamb. Furthermore, research-based recommendations have led to increased adoption of out-of-season breeding. Combined with higher levels of fertility, this has allowed producers to sell more lambs during the months with the highest lamb prices. In West Virginia, the net result has been increased revenue of 15% to 20%. Research has also helped farmers cut feed costs and reduce losses due to parasites.

These improvements to productivity and quality increase the competitiveness of the U.S. sheep industry with other major sheep producing countries. A viable sheep industry contributes to sustainable agricultural practices and provides economic stability to rural communities.

Selected Research Findings & Impacts

FEEDING PRACTICES

- **Cornell University:** Research on the effects of fermentable fiber in diets for weaned lambs has helped farmers balance the pros (improved animal health) and cons (reduced growth rate) of incorporating fiber in lamb diets.
- **South Dakota State University:** Research on soyhulls and distiller's dried grains (DDGS, a nutrient-rich co-product of ethanol production) has provided sheep producers with cost effective alternatives to conventional starch-based diets. Following NCERA-214 recommendations and outreach activities, thousands of commercial ewes in the region are now offered soyhulls or soyhulls/DDGS mixtures. Those producers report lower labor costs and other production costs and improved animal performance.
- **Virginia State University:** soyhull pellets (a source of digestible fiber) incorporated in hay-based rations increased feed efficiency and growth rate in eight-month-old lambs.
- **University of the Virgin Islands:** weaning lambs at 120 days could save tropical hair sheep producers about \$11 per animal.

BREEDING

- NCERA-214 research has helped producers make informed decisions about whether to raise Dorper breed sheep and how to manage these sheep, filling a gap in information and comparative studies on a breed that is relatively new to the U.S.
- Utilizing the sheep Eazi-Breed device for controlled internal drug release to synchronize the breeding period for ewes in fall and winter-spring reduces lambing period labor requirements by 50% or two hours per ewe annually.
- **U.S. Meat Animal Research Center:** Highly productive crossbred ewes can be produced by using either rams or ewes of prolific breeds; therefore, producers can use the breeding system that is most convenient for their situation.

FERTILITY & LAMB MORTALITY

- **U.S. Meat Animal Research Center:** Producers can overcome the seasonal constraint of fertility rate by using Romanov crossbred ewes, which had fertility rates of 87% to 89% when exposed during May (compared to 60% to 70% using Dorset, Finnsheep, and Rambouillet ewes), regardless of the remaining breed composition.
- **Cornell University:** Pasture lambing had the same lamb mortality as barn lambing for ewes that had not pasture-lambed for generations.

PARASITE & DISEASE CONTROL

- **USDA-ARS, Louisiana State University, Auburn University & Fort Valley State University:** *Sericea lespedeza* (a perennial legume) can be included in sheep diets to help control gastrointestinal nematodes (parasitic worms). Producers who graze sheep on fresh or preserved *sericea lespedeza* can expect to save more than 50% on dewormer treatments. With *sericea lespedeza* as a viable substitute, available vermifugal drugs that expel parasitic worms could have extended useful life before the parasites develop resistance. *Sericea lespedeza* is also a good option for organically produced animals, which lose their organic status if treated with certain vermifuges. A patent and a USDA-NIFA Small Business grant was awarded to facilitate commercialization of a pelleted product.
- **Virginia State University:** Incorporating juniper leaf meal into lamb diets can help control parasites and lower lamb mortality.
- **University of Rhode Island:** Oral vitamin E supplementation, at the level currently recommended by the National Research Council, significantly reduced worm presence in lambs and reduced egg count in their feces.
- **Cornell University:** A vaccine against pinkeye administered by skin scratching was effective.
- **Louisiana State University:** Copper treatment in the form of copper oxide wire particles was more effective than copper sulfate for controlling intestinal nematode infection in lambs during summer grazing season.
- **Utah State University:** A genome scan identified a genetic region that may control parasite resistance in two U.S. sheep breeds. Genetic markers for parasite resistance can be used to evaluate flocks and identify resistant and susceptible animals.
- **U.S. Meat Animal Research Center:** A genotyping test for ovine progressive pneumonia (one of the most costly sheep diseases in the U.S.) was developed for commercial use.

WORKSHOPS & OUTREACH

- **University of Wisconsin-Madison:** The only dairy sheep production research unit in North America provides research and outreach necessary for continued growth of the dairy sheep industry in the U.S., Canada, and Mexico. In 2009, the Wisconsin Sheep Dairy Cooperative more than doubled the amount of sheep milk marketed in 2003.
- **Michigan State University:** Michigan sheep producer organizations had record increases in membership in 2011, with growth directly linked to educational efforts according to survey results from outreach programs. In particular, enrollment in accelerated production systems went from zero to 10 farms and a total of 4,820 ewes in Michigan in just one year.
- Industry grant support was secured to facilitate the South Dakota sheep education program (sheepSD) for beginning farmers and ranchers.
- **University of Rhode Island:** Producers who participated in farm visits during the summer of 2011 felt that the program helped them to identify animals susceptible to parasites and evaluate vermicide resistance on their farms.
- **University of Maryland:** The Small Ruminant Extension Program has become a leader in using Internet technologies to disseminate research-based knowledge to producers. Web sites and social media have further extended reach and engagement.

Want to know more?

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This Impact Summary was compiled and designed by Sara Delheimer.



Research at the South Dakota State University Sheep Unit Lamb Nutrition Feedlot has led to alternative feeds for sheep.

Drainage Design & Management Practices to Improve Water Quality

NCERA-217 (2009-2014)

Drainage Improves Agricultural Land, but Impacts Surrounding Environment



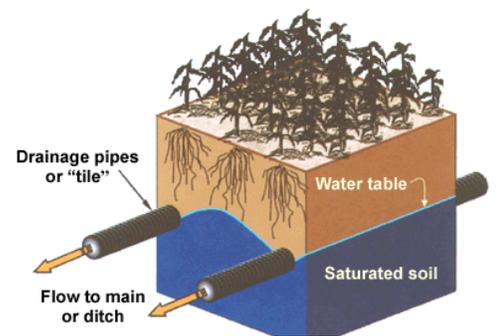
Subsurface “tile” drainage lines, which help move water off agricultural fields, may deposit nutrients and agrochemicals at the drainage outlet. USGS photo.

In the North Central US, farmers often need to improve drainage on their land. Drainage reduces soil compaction, makes it easier for farm machinery to operate, enhances field conditions for planting and harvesting, and decreases crop damage from excess moisture. In a subsurface—or “tile”—drainage system, a network of “tile lines” are installed below ground. These pipe-like lines channel excess water from the soil off the field. Despite the benefits of draining agricultural lands, subsurface drainage systems can lead to water quality issues. Nitrate, phosphorous, chemicals, and bacteria from fertilizers, pesticides, and manure that were applied to the land can make their way through the drainage system into lakes, streams, rivers, and groundwater. To simultaneously meet production goals and minimize negative environmental impacts, farmers need improved drainage systems. Cover crops, vegetated buffers, more efficient use of fertilizers, and other agronomic management practices may complement improved drainage system designs and minimize environmental impacts; however, more information is needed to use these practices effectively and economically.

Multistate Research Project Tests Drainage Systems & Water Quality

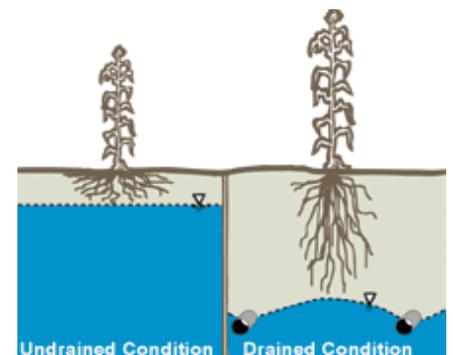
For the past five years, Multistate Research Project NCERA-217 coordinated research and extension to improve agricultural drainage design and management. Bringing together scientists with a range of technical expertise and cross-regional perspectives, NCERA-217’s findings are nuanced and broadly applicable.

Early on, NCERA-217 developed new models to evaluate the impacts of various drainage systems on hydrology, nutrient loss, and crop yield. To identify effective drainage designs, researchers tested different drainage depths and intensities. Scientists also ran tests to quantify the water quality benefits of placing different structures—like bioreactors, saturated buffers, wetlands, and vegetated ditches—at the edge of fields to remove nitrates and phosphorus from drainage water. Based on study results, the group worked with the USDA-NRCS to help establish design standards for some of these practices. NCERA-217 also quantified the amount of nitrate that land covers, such as living mulch, winter cover crop, perennial grass, and native prairie, kept from entering into subsurface drainage systems. Other studies indicated that phosphorous transport to subsurface drains is most likely to occur in soils with pores greater than one millimeter in diameter and in cracked soils where liquid manure or inorganic fertilizers have been applied to the surface. Building on these findings, NCERA-217 researchers identified practices that can help reduce phosphorus transport via subsurface drainage systems. These practices include tilling the soil above the drainage lines before applying fertilizer, avoiding applications on wet ground and less than one full day before a forecasted rainfall, and using lower application rates.



Improved Drainage Reduces Water Quality Problems, Sustains Productive Farms

NCERA-217 findings were used by state governments to develop drainage practice standards that improve water quality. For example, Iowa’s response to the Gulf of Mexico Task Force Action Plan relied on research results from many group members. At the national level, the NRCS developed Interim Conservation Standards #739 “Vegetated Subsurface Drain Outlet” and #747 “Denitrifying Bioreactor” as well as Conservation Practice Standard #554 “Drainage Water Management” based on the group’s work. These standards are a necessary first step toward farmers adopting sustainable practices. For example, since a national conservation standard was put in place, farmers can apply for cost-share to install bioreactors, dramatically increasing producer interest in this practice.



Subsurface drainage systems can improve agricultural lands and promote healthier crops. Graphics by University of Minnesota Extension.

Because of NCERA-217's extension efforts, farmers adopted improved drainage water management techniques and cropping system management practices. University of Minnesota education programs increased adoption of controlled drainage practices that are decreasing drain outflow and nutrient losses. The development of an automated drainage water control structure and effective bioreactors is revitalizing controlled drainage in eastern North Carolina. After Cornell University outreach activities, producers, contractors, and confined animal feeding operation advisors are paying more attention to vulnerable subsurface drainage outlets and adjusting their manure application methods, rates, and timing accordingly. The drain spacing calculator developed by NCERA-217 has been used in 44 countries and 36 states, and DRAINMOD models developed by the group are used by researchers worldwide. These models are essential tools for assessing climate change adaptation strategies for forests and agricultural systems on drained lands.

Implementing improved drainage water management has led to a significant reduction in nitrogen, phosphorus, and other contaminant losses from drained lands and a dramatic reduction of associated water quality problems. Best management practices for applying manure and biosolids on drained land have reduced contamination of surface and groundwater and lowered health risks. Using these systems has allowed farmers to drain land and boost crop yields without degrading the surrounding environment. Improving drainage has also reduced variability in crop yields from year to year, which allows a more stable source of food for consumers and predictable profits for farmers.

Extension Improves Awareness & Boosts Adoption

Members of NCERA-217 acquired more than \$27,000,000 in grants to extend research and education efforts on drainage issues. The group developed strategies to facilitate communication between scientists and policymakers and promoted partnerships with stakeholders. Several members used funds to create publications, bulletins, web sites, and other educational materials about drainage design and management systems. NCERA-217 scientists also gave television and radio interviews, and numerous popular press articles were written about the project. Members gave presentations at a wide variety of meetings and conferences for state and national level trade and regulatory organizations. The group also hosted drainage schools and workshops. Participants at the Iowa Drainage School indicated that the program will help them design more effective drainage systems that will improve their bottom lines. Participants at NCERA-217 workshops reported gaining useful knowledge that gave them more confidence in designing drainage systems and avoiding mistakes. Thousands of stakeholders attended field days organized by NCERA-217 members. Face-to-face discussions and hands-on learning at these events increased awareness of the value of protecting soil and water quality and increased their knowledge of new techniques and tools for managing drainage.

Want to know more?

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Purdue University
South Dakota State University

Industry Partners
Agricultural Drainage Management Coalition
Agri Drain Corporation, IA
Ecosystems Exchange, FL
Prinsco, MN
Springfield Plastic, IL
Trimble, OH

NGO Partners
Farm Bureau, SD
Illinois Soybean Association
Iowa Drainage District Association
The Nature Conservancy

Participating Government Institutions
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EPA, Region 5
Minnehaha County, SD
Minnesota Department of Agriculture
North Dakota Water Commission
South Dakota Department of Agriculture
USDA-ARS
USDA-NRCS

Impact Statement compiled by Sara Delheimer.



Above, USDA-ARS ecologist Matt Moore and soil scientist Martin Locke assess the biomass of plants growing in a vegetated drainage ditch and test to see how well the ditch reduces agricultural pesticide and nutrient runoff. Below, soil scientist Norm Fausey adjusts a drainage water management structure to change the depth of the drainage outlet. Photos by Peggy Greb, USDA-ARS.



Hydromorphic Soils

NE-1038 (2009-2014)

The Importance of Wetland Soils

Soils form in the presence of excess water in riverine, coastal, permanently submerged (subaqueous), and other wetland areas across the northeastern US. Federal, state, local, and private entities have requested information about these soils in order to manage shellfish stocks, plan dredging and waste disposal, and construct stable roads, bridges, docks, and dams. Fluctuations in water levels also affect the ability of wetlands to store carbon and filter water.

Managing these soils and the resources and activities that depend on them requires an understanding of hydrology—the movement, distribution, and quality of water—among these soils and how it varies across the region. Legislative decisions about wetlands require more precise mapping. Identifying hydric soils (soils that are permanently or seasonally saturated by water) is a key to on-site delineation of wetlands. However, some hydric soils fail to develop the typical morphology of wetland soils and are difficult to identify without revised guidelines and tools.



NE-1038 scientists are trying to get a picture of what is happening to subaqueous soils impacted by aquaculture. The condition of the soils is indicative of water quality, tidal fluctuation, and how much energy is coming in. University of Rhode Island photo.

Multistate Research Project Improves Soil Identification & Soil Resource Management

Soil scientists are working together under Multistate Research Project NE-1038 to improve identification, classification, and management of hydromorphic, hydric, and subaqueous soils. The multistate approach enabled researchers to sample soils and conduct studies in a wide variety of climates and wetland settings.

NE-1038's research has increased the amount of data for soils that were previously difficult to sample and under-represented in the national soils database. Participating scientists documented physical and chemical properties of hydromorphic, hydric, and subaqueous soils. NE-1038 researchers also evaluated potential indicators of hydric soils and identified specific indicators that can be used in the field to assess wetland hydrologic characteristics. Based on work at sites in Delaware, Maryland, Pennsylvania, and West Virginia, new hydric soil indicators were incorporated in region-wide guidelines. These indicators could impact wetland restoration efforts by helping to assess pre-disturbed hydrology. Researchers also developed better models to predict the landscape distribution of hydric and subaqueous soils. Soil characterization and distribution modeling augments wetland mapping in the region. Better soil data and mapping are critical to region-wide efforts to assess impacts on the ecosystem services that soils provide. For example, Rhode Island researchers used field tests and models to predict the best soils for oyster aquaculture and measure the impact of sedimentation and ocean acidification on oyster survival.

At Pennsylvania State University, NE-1038 scientists assessed the impacts of fracking on wetlands. Researchers installed soil moisture, temperature, and groundwater pressure sensors to monitor the water table in the vicinity of natural gas development sites. Sensor data were used to develop more accurate models of wetland areas susceptible to damage from gas infrastructure. Researchers also documented that drilling infrastructure is changing surface hydrology of the landscape. Altering the hydrology of an area can have detrimental effects on existing vegetation, amphibian habitat, and carbon storage as well as road placement and maintenance. Understanding how fracking disturbs the land and hydrology is critical to protecting both natural resources and the built environment.



NE-1038 scientists extract cores of sediment from wetlands to look at soil characteristics like color, porosity, and carbon content. Photos by Jim Turenne, USDA-NRCS.



NE-1038 scientists dig holes in research plots on wetlands to measure soil layers and see how water moves through the soil. Photos by Jim Turenne, USDA-NRCS.

Want to know more?

This project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. Additional funds were provided by contracts and grants to participating scientists. For more information: <http://nera.umd.edu>.

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- University of Kentucky
- University of Maryland
- University of Massachusetts
- Pennsylvania State University
- University of Rhode Island
- Virginia Polytechnic Institute and State University
- West Virginia University

Impact Statement compiled by Sara Delheimer.

Pennsylvania State University researchers also developed a model that predicts excess saturation across the landscape. This model is laying the foundation for development of a real-time, online weather forecasting tool that will help farmers determine when fertilizer should be applied in the Chesapeake Bay watershed.

Based on study findings, NE-1038 scientists developed better methods for quantifying soil organic carbon in different wetland soils. Rhode Island researchers found that subaqueous soils sequester as much carbon as terrestrial soils, suggesting that global carbon accounting metrics be revised to more strongly consider subaqueous soil sequestration. More accurate measurements of soil carbon also helped scientists model the effects of wetland condition (from pristine to degraded) on the amount of carbon stored. Maryland scientists found that soil organic carbon stocks were substantially greater in natural landscapes when compared with landscapes drained or cultivated for agriculture in the Delmarva Bay area. Findings like this illustrate the benefits of wetland restoration on carbon sequestration. Furthermore, University of Maryland scientists showed that the marshes Maryland's coastal communities depend on will disappear as sea level rises if the soils are unable to store biomass and organic carbon. Altogether, NE-1038's data and models are critical for developing strategies to increase carbon sequestration in soils and minimize global warming.

NE-1038 Data Used Widely

NE-1038's multistate framework has made findings and data more useful to major agencies, such as the USDA, Army Corps of Engineers, and Environmental Protection Agency, which all work in a region-wide context. For example, working groups, like the Mid-Atlantic Hydric Soils Committee, who offer guidance to regional regulatory bodies (e.g., the New England Water Pollution Control Commission) were able to use soils information from NE-1038 because it is not restricted by state boundaries. NE-1038 also provided soil characterization data to the Natural Resources Conservation Service (NRCS) for their national soils database, and five new soil series were accepted by the NRCS Soil Survey Division. Additionally, NE-1038's approach to classifying shallow water substrate was approved by the Federal Geographic Data Committee and included in the national Coastal and Marine Ecological Classification Standard.

Over the past five years, NE-1038 has provided a forum for disseminating information about wetland systems and associated soils. NE-1038 scientists have been responsible for most of the hydric soils training received by the soil science professional and regulatory communities. For example, the group led the annual Northeast Regional Pedology Field Tour for graduate students, NRCS soil scientists, and other agency leaders. NE-1038 also hosted a workshop on identifying, evaluating, and testing hydric soil and trained over 20 members of the Mid-Atlantic and New England Hydric Soil Technical Committees to better estimate soil organic carbon content. Data from NE-1038 studies are also being used to train Pennsylvania Bureau of Forestry personnel to monitor soil and hydrologic changes due to shale-gas infrastructure.

Improving Older Adults' Health Trajectory through Diet & Activity Modifications

NE-1039 (2009-2014)

Diet & Exercise Among Older Adults

Over one-third of adults over age 75 in the U.S. have three or more chronic conditions, such as cardiovascular disease, eye disease, certain cancers, and obesity. Ethnic minorities and low income populations are most at risk. Regular exercise and a diet rich in fruits, vegetables, and whole grains can lower the risk of many chronic conditions. Despite these benefits, only 6% of older adults consume at least three daily servings of vegetables, and only 4% of older women and 11% of older men consume at least six daily servings of grain products. Fewer than 10% of adults over age 64 engage in physical activities that enhance and maintain strength, endurance, and cardiorespiratory fitness more than two days per week.

Older adults who are disabled by or hospitalized for largely preventable, diet-related diseases represent a disproportionate amount of national health care costs. If older adults' health trajectories are not improved, health care costs will skyrocket as the baby boom generation ages. Even when implemented later in life, changes in diet and exercise can effectively improve quality of life and reduce the strain on the health care system.

Multistate Project Creates Programs & Tools to Encourage Healthy Habits, Reduce Risks for Seniors

Over the last five years, Multistate Research Project NE-1039 has brought scientists together to share responsibilities and resources, standardize methods, and recruit subjects in order to research and develop effective diet and exercise interventions for older adults.

NE-1039 developed educational curricula for teaching older adults about the benefits of increased fruit, vegetable, and whole grain consumption and created motivational curricula to encourage seniors to adopt healthy eating habits. Researchers also identified strategies to increase physical fitness.

Strategies included developing a specialized program for overweight older adults to reduce coronary heart disease risk. NE-1039 also designed materials and trained leaders for the LIFE Program, a community-based, intergenerational “exer-gaming” program implemented at rural meal sites.

To pilot new intervention programs, NE-1039 conducted focus groups, surveys, and regular evaluations. Researchers analyzed data from the programs to determine which exercise regimes and diets are having the greatest impact on health. As part of this effort, scientists identified effective biomarkers that indicate improved diet, physical functioning, and chronic disease risk in older adults. For example, scientists assessed how lutein affects macular pigment density and eye disease risk and collected data that showed how dietary folic acid affects cholesterol, triglycerides, glucose, and cognitive function.

NE-1039 members also revised existing programs. Modeling tools developed by NE-1039 pinpointed areas where programs were falling short, for instance, areas where older adults have limited nearby options for nutritional foods. These models helped researchers and communities extend programs and other resources to fill these gaps. For example, NE-1039 designed a more efficient system for delivering food to meal site programs and came up with ways to improve the food safety of home delivery meals. The team also designed models to determine how certain life events and lifestyle factors affect older adults' health, so that programs can take these factors into account. Using these models, researchers found that as a woman's age, body mass index (fatness), and number of pregnancies increase, the probability of being diagnosed with adult macular degeneration increases.



Older adults who are also ethnic minorities are more likely to be at risk of a chronic disease. Often, these risks can be reduced by eating more fruits, vegetables, and whole grains and increasing physical activity. Top photo courtesy of the National Institute on Aging. Bottom photo courtesy of City of North Charleston, Flickr, CC BY-SA 2.0 License.

NE-1039 Programs Impact Older Adults' Health

Revising existing programs and creating new ones ensures that diet and physical activity interventions are effective for a growing and diverse population of older adults. With more precise biomarker indicators, health assessments are better able to measure disease risks and intervention impacts. Over 900 older adults have been screened for diet-related risks since the start of NE-1039. Early identification of health risks could save individuals \$1,500 in annual health care costs if they make recommended lifestyle changes. Collectively, the NE-1039 project has provided over 5,100 older adults access to nutrition and/or physical activity interventions and other resources that have had remarkable impacts:

- Communities have used NE-1039's model to illustrate gaps in availability of nutritious foods, opportunities for physical activity, and programs that support these habits. This has helped programs reach those who are in need.
- 50% of older adults participating in the whole grain foods education program have increased their whole grain food consumption.
- 50% of older adults visiting congregate meal sites in Washington, D.C. have increased their intake of fruits, vegetables, and whole grains.
- 50% of older adults receiving home-delivered meals have changed their food safety practices at home, reducing their risk of food-borne illness.
- After six months, participants in a monthly nutrition program at group meal sites had lower nutritional risk.
- Older adults who were at risk for obesity-related disabilities and morbidities have improved health indicators.
- The LIFE program has improved functional fitness, wellbeing, and readiness to change among older adults while reducing ageism among young adults. Of the 21 participants in the LIFE Program who were classified as inactive at Week 1, five became active by Week 8, and six more became active by Week 25. All participants increased the number of chair stands they were able to complete in 30 seconds, handgrip strength, and flexibility during the program.



Want to know more?

The NE-1039 project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1888) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. Additional funds were provided by contracts and grants to participating scientists. For more information, visit <http://nera.umd.edu>.

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Participating Institutions:

University of the District of Columbia
Iowa State University
Louisiana State University
University of Maryland
University of Massachusetts
University of Missouri
University of New Hampshire
New Hampshire Cooperative Extension
Rutgers University
University of Rhode Island
West Virginia University

This Impact Summary was compiled by Sara Delheimer.

As part of the LIFE program run by NE-1039 researchers, young adults and older adults do exer-gaming activities together to improve fitness (top photo, courtesy of Iowa State University Extension and Outreach). NE-1039 researchers and Extension agents also host food demonstrations for seniors to teach them about healthy foods and appropriate portions and give them ideas for how to incorporate more fruits, vegetables, and whole grains in their meals (middle and bottom photos, courtesy of the University of the District of Columbia).

Environmental Impacts of Equine Operations

NE-1041 (2009-2014)

Impacts of Equine Operations Spread beyond the Farm

The Northeast and Mid-Atlantic states are home to more than 428,000 horses, ponies, and mules living on about 65,000 farms. These farms can have far-reaching environmental effects. Poor horse pasture and trail management combined with heavy horse hoof traffic can lead to problematic soil erosion. Runoff can carry eroded sediment and pollutants (like nitrogen, phosphorous, and bacteria from horse feed, manure, and bedding) off the farm and deposit them in nearby soils and bodies of water. Each horse produces approximately 50 pounds of manure per day, for a total of over 3.9 million tons of manure in the region each year. To avoid the cost of disposing of waste off the farm, many horse owners apply manure to pasture and hay fields. Because horse stall manure often contains bedding material and parasites, over-applying manure can limit the growth of pasture grasses and hay. Horse owners need affordable, environmentally friendly alternatives for waste disposal. With nutrient analyses of different kinds of forage, farmers would know how to better meet horses' dietary needs and minimize excretions of excess nutrients.



The impacts of horse farms can spread far beyond the individual farm, affecting the surrounding area's soil, water, and air quality. Photo courtesy of Carey Williams, Rutgers University.

Multistate Project Develops Strategies for Environmentally Friendly Horse Farms

In 2009, experts on horses, farm management, and soil, water, and air quality formed Multistate Research Project NE-1041 "Environmental Impacts of Equine Operations." These scientists developed reliable methods for measuring nutrient and pathogen levels on farms. They also created models to understand the origins and destinations of pollutants. Using these models, the group identified feeding and pasture and stall management strategies to minimize the environmental impacts of horse farms.

Many NE-1041 studies focused on ensuring horse nutrition by improving feeding strategies and pasture management. These strategies have reduced feed waste and associated costs.

- Rutgers University researchers compared effects of rotational and continuous grazing on pasture health, soil quality, horse health, and production costs.
- North Carolina State University scientists refined methods for predicting and regulating pasture dry matter intake.
- Studies at the University of Minnesota investigated horse preference for and nutrient value of different forages. For example, a University of Minnesota study showed that spring wheat is a high-yielding forage that is palatable to grazing horses and may be a viable option for horse owners in need of emergency pasture forage when grasses and legumes are injured or killed during cold winter weather. Researchers also showed that mixing certain legumes with grasses can increase pasture forage yield as well as the amount of crude protein and digestible energy horses consume. In field trials, researchers determined that a grazing muzzle reduced a horse's pasture intake by 30%.
- NE-1041 research findings have given horse farmers better choices for hay feeding, including new hay feeder designs that can reduce feed waste. Researchers also illuminated ways to efficiently feed small-square hay bales in outdoor paddocks, which has helped reduce hay waste and associated costs.
- University of Massachusetts researchers tested a paddock system that delivers feed and water at different points along a track. Owners who adopted the system said their horses get more exercise and are healthier than on typical dry lots.
- To predict whether weeds commonly found on dry lots can trigger laminitis episodes, University of Minnesota researchers analyzed the weeds to determine if they are palatable to horses and high in carbohydrates. Laminitis is a painful condition for horses that leads to decreased performance, increased veterinary costs, and even horse death.
- Rutgers University studied the influence of diet on nitrogen and phosphorous excretion in manure. Studies showed that overfeeding of phosphorus supplements may result in more water soluble phosphorus present in manure. Based on NE-1041 findings, some horse owners have adopted feeding strategies that reduce nitrogen and phosphorus in horse diets; however, NE-1041 continues to explore ways, including cost-sharing programs and compliance, to encourage horse farmers to adopt recommendations.

NE-1041's work has increased implementation of sustainable stall and waste management practices that improve air, water, and soil quality in and around horse paddocks. For example, horse owners have adopted and promoted heavy use area pads because

of demonstrations by NE-1041. These pads have reduced mud in high traffic areas on farms. Less mud lowers the risk of slips and injury, limits bugs and pathogens harbored in muddy areas, and reduces runoff. To optimize practices for adding horse manure to soils to improve quality, researchers developed a training course for horse owners and managers with composters. Composting reduces the volume of waste material, eliminates some pathogens and parasites, and improves manure's utility as a soil amendment. In these ways, composting can reduce the cost of waste disposal and reduce potential pollution. Rutgers University research teams assessed how runoff from horse manure compost piles varied with covering, turning frequency, and use of grass buffer systems. They also assessed the influence of bedding types on stall air quality and their suitability for composting.

After developing a Near Infrared Spectroscopy method, Rutgers University researchers partnered with a local bioenergy company to measure the carbon dioxide and methane in manure from a modular anaerobic digester. The study found that adding high levels of bedding increased the carbon content of manure, creating potential for horse manure to be used in gasification or combustion energy technologies. Tests also showed that wood pellet bedding was easier for the digester to chop than straw bedding.

Extension Increases Horse Owner Awareness of Issues & Adoption of Solutions

To extend their findings, NE-1041 researchers published articles in technical journals, trade magazines, and local newspapers. Project members also developed print and online materials, including fact sheets and videos, making information easily accessible to farmers.

To discuss current issues and share new technology and best practices, NE-1041 members held informational meetings with county personnel, municipal officials, environmental organizations, and local residents. In Vermont, meetings led to updated waste management regulations. The group also hosted seminars for the American Horse Council and individual state horse councils, state farm bureaus, and state departments of agriculture and environmental protection. Project members also participated in conferences, including the Livestock and Poultry Environmental Learning Center's Waste to Worth Conference and University of Florida's Manurepalooza.

NE-1041 members also installed educational exhibits with models and posters and created demonstration fields at their institutions to illustrate best management practices. South Dakota State University students in equine and waste management classes collaborated with agricultural engineering students and designed manure composting demonstration plots. The University of Massachusetts secured grants for two pilot farms to test different footing materials and evaluate a new composter. Tours of farms and demonstration fields for horse owners, farm managers, trail riders, and other stakeholders provided important hands-on learning. To date, 20 farms have participated in the University of Minnesota's Pasture Evaluation Program, which includes two visits from a specialist, a facilities assessment, and pasture, forage, and soil samples, as well as optional yearly maintenance visits.

Want to know more?

This project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. Additional funds were provided by contracts and grants to participating scientists. For more information: <http://nera.umd.edu>.

Administrative Advisor: Mark Rieger (mrieger@udel.edu)



NE-1041's research on hay feeders has reduced feed waste. Photo courtesy of Krishona Martinson, University of Minnesota. New composter designs and practices have provided more affordable, environmentally friendly manure disposal for horse farmers. Photo courtesy of Michael Westendorf, Rutgers University.

At their respective institutions, many NE-1041 members designed education programs related to horse and environmental stewardship. Programs through Rutgers University and Pennsylvania State University helped over 1,000 horse owners develop plans for proper manure management and nutrient management. NE-1041 is involved in over 12 different educational programs, including:

Pennsylvania State University

- Equine Environmental Stewardship Short Course, completed by 1,086 farm managers in Pennsylvania and New York
- Environmentally Friendly Farm Program
- Implementing and Marketing Environmental Stewardship on Small Farms program (a partner program with NRCS)
- Equine demonstrations and talks at the 2012 and 2015 North American Manure Expos

Rutgers University

- Gold Medal Horse Farm, Environmental Stewardship Program
- Compost Certification Online Course
- Diet management program for 20 horse farms in New Jersey focused on the environmental benefits of optimal feeding techniques on horse farms

South Dakota State University

- Healthy Lands, Healthy Horses
- Stable Management and Animal Waste Management classes
- Specially-designed outreach for small acreage farmers
- 4-H Horse Committee, 4-H Youth HORSE Training, Western National Roundup, the American Youth Horse Council, and other youth programs

University of Vermont

- Across the Fence television episodes about best management practices

Participating Institutions:

Auburn University, University of Connecticut, Louisiana State University, University of Maryland, University of Massachusetts, Michigan State University, University of Minnesota, North Carolina State University, Pennsylvania State University, Rutgers University, South Dakota State University, University of Vermont, Virginia Polytechnic Institute and State University

Impact Statement compiled by Sara Delheimer.

Optimizing Poultry Welfare & Production

NE-1042 (2009-2014)

Poultry Systems Face Animal and Environmental Welfare Issues

Poultry meat and eggs are popular food choices among Americans; however, consumers and the general public are increasingly concerned about animal welfare and environmental impacts of poultry production. For poultry producers, energy and resource efficient production systems are a high priority, especially as feed and fuel prices climb. Optimizing poultry welfare and resource use requires a thorough understanding of the influence of different nutrition, lighting, and ventilation strategies on poultry performance, air quality, and environmental footprint. If acceptable conditions and practices are not defined, the US poultry industry could be less competitive in domestic and global markets.

Research & Extension Activities

In 2009, Multistate Research Project NE-1042 formed to develop poultry production systems that safeguard poultry welfare, use resources efficiently, and have minimal environmental impacts. The project brings together diverse expertise, equipment and facilities, and other resources, enabling the group to efficiently tackle complex problems. The project's Extension members are in direct contact with poultry producers, facilitating the flow of information in both directions and strengthening the impact of the project.

To better monitor and measure stress in poultry, project scientists at the University of Connecticut recorded poultry vocalizations and used computer programs and models to sort different vocalizations into stress-related and non-stress classes. NE-1042 researchers measured the effects of stress on egg production, hatchability, growth rate, feed efficiency, skeletal development, and behavior.

Project members also studied ways to manipulate stressors, like heat and light, to reduce their effects on poultry. For example, scientists at the University of Georgia examined the effects of air velocity on poultry performance in tunnel-ventilated housing. Other researchers evaluated the energy consumption and cost-effectiveness of various lighting and ventilation manipulations and set parameters for lighting intensity and coverage.

NE-1042 scientists also assessed alternative hen housing systems. Enriched cages, aviaries, small group systems, and outdoor housing were evaluated based on hen welfare (hen health, behavior, physiology, and egg production and quality), resource use, indoor air quality, and environmental footprint.

Researchers at multiple participating universities examined the effects of diet manipulations on poultry welfare and performance. Nutritionists at the University of Illinois, University of Minnesota, and the University of Nebraska determined the influence of varying nutrient levels and the use of alternative ingredients (such as dried distillers grains and low-protein formulas) on energy level, feed intake, and ammonia emissions. Collaborative efforts among Iowa State University, University of California, University of Minnesota, and Pennsylvania State University led to over \$2.5 million in grants for projects to monitor and mitigate ammonia emissions from poultry operations.

During the last five years, group members published over 100 peer-reviewed journal articles, nine peer-reviewed Extension reports, 10 popular press articles, and 55 proceedings at national and international meetings. These materials are helping raise awareness of optimal poultry production conditions and new strategies and technologies to achieve those conditions.



NE-1042 researchers studied the effects of different intensities and colors of lighting on poultry welfare. Top photo by Rob Flynn, USDA-ARS. Bottom photo by Michael Czarick, University of Georgia College of Agriculture and Environmental Sciences.

Multistate Project Makes Poultry Housing and Nutrition Safer, More Sustainable

Optimizing environmental conditions and management practices is enabling poultry production systems that protect poultry welfare and performance, food safety, and environmental soundness.

- Ventilation and lighting manipulations recommended by NE-1042 are being used to improve facility designs. Adoption of recommended lighting programs and energy efficient lighting has resulted in significant savings by producers in California, Connecticut, and Georgia.
- These recommendations are further augmented by the group's economic analyses, which are helping farmers determine the most efficient and profitable housing systems for poultry.
- NE-1042's poultry vocalization classifications give operators a way to identify physical and psychological stress early on and regulate poultry welfare.
- NE-1042 data on ammonia emissions and new feed sources for poultry are being used to improve nutrition management. For example, based on NE-1042 research on ethanol co-products in poultry diets, 80% of commercial egg producers have adopted new feeding programs, and turkey producers have decreased feed costs.



NE-1042 studied feed types and feeding strategies to help improve poultry nutrition and reduce ammonia emissions, which contribute to air and water quality issues around poultry farms. Photo by Hongwei Xin, Iowa State University.



Enriched colony layer houses still use cages, but provide at least double the space of conventional cages, making sure hens have enough room to lie down, spread their wings, and turn around. They offer nests, perches, and scratching areas. Photo by Hongwei Xin, Iowa State University.



In this improved poultry building, new radiant heaters keep the chickens warm during cold weather. On warm days, ceiling vents let heat escape; when chicken house temperatures are estimated to be above 90 degrees, fans pull air through water evaporator elements, creating a tunnel of cooled air along the building. Each of these features is computer controlled, making them easy for producers to use and adjust. Chickens benefit from reduced heat and moisture, minimized dust and odor, and limited buildup of ammonia and carbon dioxide. Photo by Lance Cheung, USDA.

Want to know more?

The NE-1042 project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act to encourage and enhance multistate, multidisciplinary research on critical issues. Additional funds were provided by contracts and grants to participating scientists. For more information, visit <http://nera.umd.edu>.

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Auburn University
University of Bern, Switzerland
University of California, Davis
University of Connecticut, Storrs
University of Delaware
Delaware State University Extension
Georgia Cooperative Extension
University of Guelph
University of Illinois
Iowa State University
University of Kentucky
University of Maryland
Michigan State University
University of Minnesota
Mississippi State University
University of Nebraska
North Carolina State University
Pennsylvania State University
Purdue University
Texas AgriLife Research
Virginia Tech University
University of Wisconsin
USDA-ARS, Indiana, Georgia, Mississippi

Emerging Disease Vectors

NE-1043 (2009-2014)

Mosquito-Borne Diseases Threaten Human Health & Economy

Diseases transmitted by mosquitoes are a serious threat to human lives. Viruses transmitted to humans from mosquitoes often result in an infection that can cause brain inflammation, which can result in death or severe neurologic after-effects. Incidence is on the rise as new diseases and vectors emerge and spread, often fueled by international travel. As a travel and immigrant destination, the U.S. must protect itself from diseases in other parts of the world, such as malaria. Each year there are 300 to 500 million cases of malaria reported, resulting in up to 2.7 million deaths, mostly children. Other diseases have already emerged in the U.S. Mosquitoes in the U.S. transmit several serious viruses including St. Louis, LaCrosse, eastern and western equine encephalitis, and West Nile virus. Nearly 40,000 people in the U.S. have become infected with West Nile virus with over 1,600 deaths recorded to date. The elderly and children are at particular risk of developing serious illness.

The economic impact of mosquito-borne illness is devastating. The cost of treating West Nile virus infections has been immense, with Louisiana alone estimating \$70 million in 2002. Many of these viruses also threaten the equine industry. The mortality rate of horses infected with West Nile virus is 34 percent; the rate for those with eastern equine encephalitis is 100 percent. In 2000, the estimated loss in New Jersey due to equine cases of West Nile virus was \$6 million. Tourism is also impacted by outbreaks of mosquito-borne disease.

Despite medical advances over the years, there are no vaccines, antibiotics, or treatments for most of these viral infections. Instead, mitigation focuses on controlling the mosquitoes that transmit the diseases. Scientists must provide safe, affordable, effective ways to prevent and control outbreaks of diseases transmitted by mosquitoes.



Aedes albopictus. Photo by the Connecticut Agricultural Experiment Station. In a laboratory, mosquitoes are identified under a microscope. Some species can disease-causing viruses. Washington Department of Health.

Multistate Research Project Helps Manage Mosquitoes & Disease

Since forming in 2007, Multistate Research Project NE-1043, “Biology, Ecology & Management of Emerging Disease Vectors” has shared resources and coordinated research to provide valuable insights, data, and tools to help manage mosquito-borne disease. During the last five year period of the project, researchers’ work on these objectives has led to many meaningful impacts.

Strengthened research and improved knowledge. Unraveling ecological relationships between pathogens, vectors, hosts, and the environment has helped develop economical and effective management programs for mosquitoes. This information has also saved pest control agencies time and money by helping them know which strategies to devote resources to.

- Research led to an enhanced understanding of mosquito biology and interactions between hosts and mosquitoes across an array of ecosystems.
- Determined that the invasive mosquito species *Ae. j. japonicus* has potential to be a bridge vector because of its high prevalence of human blood feeding, local abundance, and repeated detection of West Nile virus.
- Research resulted in a better understanding of the host selection patterns of *Culex pipiens* mosquito populations, which are the primary vector mosquito species for West Nile virus.
- Obtained new insights on how mosquito-borne viruses overwinter, persist, and circulate in mosquito populations in the northeastern U.S.

Developed more detailed and reliable models. Models and the information they display have helped pest control agencies predict disease outbreaks and spread, making it possible for them to ward off or prepare for epidemics. Improved

models have also saved time and money by showing pest control agents which mosquitoes and areas to target. For example, members of NE-1043 developed:

- A risk model for eastern equine encephalitis and made it available via a website, making it easier for users to predict and control the disease.
- A model for predicting West Nile virus foci and transmission.
- A climate-based model to evaluate the epidemic potential of Chikungunya virus if it is introduced to the U.S.

Enhanced surveillance and monitoring. Improved detection strategies have helped stall the spread of mosquitoes and the diseases they carry. Mosquito and virus surveillance programs have provided an early warning system for interventions by local mosquito control agencies, helping them catch problems before they get out of hand. NE-1043 has also made sure that surveillance and monitoring equipment is easier to use and maintain. In addition, by making sure that tools for disease detection are fast and accurate, NE-1043 has helped identify hot spots and outbreaks before they spread very far. For example, NE-1043:

- Evaluated new methods for mosquito trapping in the field.
- Validated the Rapid Analyte Measurement Platform system as a fast and reliable tool for detecting West Nile virus.

Improved mosquito control options. NE-1043's research and recommendations have encouraged scientifically based, environmentally sound control by local mosquito control agencies.

- Moved novel technologies and new chemical insecticides from the bench to operational use.
- Discovered new biological control agents and evaluated existing biologic agents in a variety of mosquito breeding habitats.
- Developed new bacterial toxins with enhanced virulence against mosquito larvae and the potential to be produced commercially as a low risk biological insecticide.
- Used cutting-edge molecular methods to identify critical proteins and utilized gene silencing (RNA interference) to disrupt mosquito survival and reproduction for population control.

Widened the reach of information and training. NE-1043 have participated in graduate student and postdoctoral training programs and reported their research findings within the scientific community and with the general public, helping to encourage the widespread adoption of sustainable mosquito and disease management.

Want to know more?

The NE-1043 project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund (MRF) established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1888) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. Additional funds were provided by contracts and grants to participating scientists. For more information, visit <http://nera.umd.edu>.

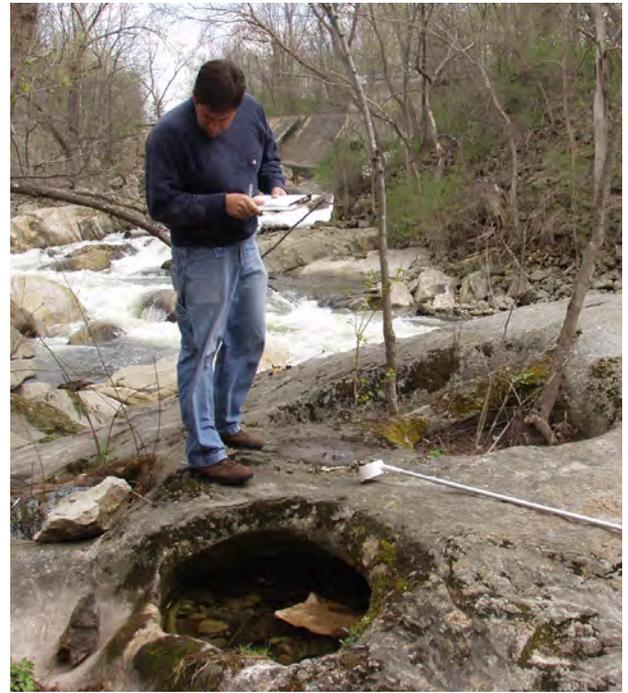
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Connecticut - New Haven
Cornell University
University of Delaware
University of Kentucky
University of Maryland
University of Massachusetts
Michigan State University
University of Minnesota
University of Nebraska

Ohio State University
Rutgers University
Texas AgriLife Research
University of Wisconsin
USDA-ARS
USDA-ARS Florida
USDA-ARS Center for Grain and
Animal Health Research



Monitoring area mosquitoes can help detect the presence of viruses before they spread to humans. In the top photo, a researcher surveys rock hole breeding sites for *Aedes japonicus*. Mosquito traps like the one shown in the photo above utilize attractants like light and heat, light and carbon dioxide, or hay-infused water. Once the adult mosquito is lured in by these traps, it is then blown into the net by a fan. Photos by the Connecticut Agricultural Experiment Station.



Culex pipiens. Photo by the Connecticut Agricultural Experiment Station.

This Impact Summary was compiled and designed by Sara Delheimer.

National Research Support Project Impacts

National Atmospheric Deposition Program

NRSP-003 (2009-2014)

Tracking Atmospheric Deposition and its Effects

Gases and particulates released into the atmosphere eventually settle to the ground as dry deposition or fall to the earth in rain and snow as wet deposition. The chemical pollutants and biological pathogens in atmospheric deposition can accumulate in soils and bodies of water and make their way into plants and animals, including the foods we eat. The National Atmospheric Deposition Program (NADP) provides continuous national-scale measurement of atmospheric deposition amounts, geographic distribution, and trends across North America. By monitoring the flow of pollutants into the biosphere, NADP data support research and education about the effects of deposition on ecosystems, agricultural systems, cultural artifacts, and human populations. Through this work, the NADP helps foster environmental stewardship, ensure food safety and human health, and improve agricultural productivity.



An NADP site was recently set up at North Carolina Agricultural & Technical State University.

National Research Support Project Provides Integral Support to NADP

Since 1993, the NADP has been designated a National Research Support Project (NRSP-3). As such, the NADP has been able to bring together scientists, educators, and policymakers from Agricultural Experiment Stations (SAES), universities, government agencies, national forests and laboratories, Native American tribes, environmental institutes, private companies, and other organizations into a cohesive monitoring network. NRSP-3 provides a framework for sharing financial, human, and technological resources.

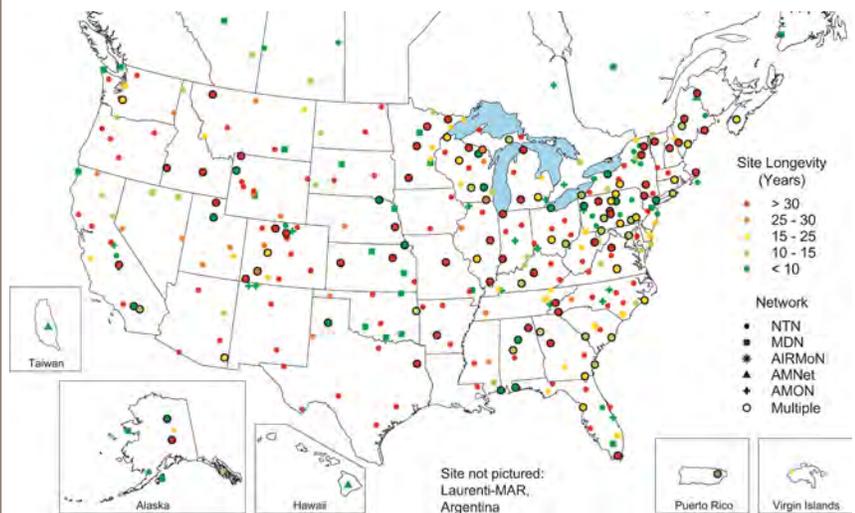
The NADP operates five monitoring networks (see table below): the National Trends Network (NTN), the Atmospheric Integrated Research Monitoring Network (AIRMoN), Mercury Deposition Network (MDN), Atmospheric Mercury Network (AMNet), and Ammonia Monitoring Network (AMoN). With multistate, multidisciplinary participation, the NADP is able to efficiently manage these networks and quickly respond to emerging needs. For example, the NADP:

- Facilitated conversion of precipitation gages to an all-digital network
- Developed new monitoring networks for mercury in litterfall (leaves, twigs, etc.) and pathogen spores (in partnership with the USDA Cereal Disease Laboratory)
- Added the ability to detect the analyte bromine (a strictly regulated, ozone-depleting substance) in precipitation
- Tracked wet deposition from the Fukushima nuclear incident in Japan

NRSP status leverages considerable federal and state funding and much lower costs for NADP site sponsors. SAES provide \$50,000 in direct support to the NADP, resulting in a 70 to 1 leverage of direct support dollars (approximately \$3.5 M). Loss of NRSP-3 funding and coordination would likely result in the shutdown of monitoring at many sites.

NADP Monitoring Networks & Sites

	NTN	AIRMON	MDN	AMNet	AMON
First Sampling Year	1978	1992	1996	2009	2010
Years of Operation	38	24	20	7	6
# Active Sites	265	6	115	24	99
Collection Frequency	weekly	event-based	weekly	continuously	two-week
Analytes	SO ₄ ²⁻ , NO ₃ ⁻ , NH ₄ ⁺ , pH, Ca ²⁺ , Mg ²⁺ , K ⁺ , Na ⁺ , Cl ⁻ , Br ⁻ , PO ₄ ³⁻		Hg wet deposition	gaseous elemental and oxidized Hg, particulate bound Hg	ammonia gas
Approximate # of Historical Samples	410,000	30,000	95,000	1,000,000	11,000



The top map illustrates the multistate nature of the NADP. The bottom map shows SAES sites that collect measurements within the NADP. SAES sites are key to the NADP's success.

NADP Data Help Protect Ecosystems, Resources, Food Security & Human Health

The NADP has provided free and easy access to all of its data, seasonal and annual averages, trend plots, deposition maps, reports, manuals, and educational brochures through the NADP website (<http://nadp.isws.illinois.edu>). Consistent screening procedures have assured the quality of NADP data.

NADP data are used frequently to inform and evaluate environmental policies. For example, NADP maps were used by the EPA in support of the *Clear Skies Initiative*, and the EPA Clean Air Markets Division uses NADP data in its annual reports. The International Joint Commission uses NADP data in periodic evaluations of the US-Canada Air Quality Agreement. NADP data can be used track pollutants and discern sources, important information for policy and legal actions.

NADP data is critical to public safety. In 1996, only 39 states had advisories to limit consumption of fish because of mercury contamination. Today, the count has risen to 49 states. NADP data played a key part in understanding the impact of the 2011 Japanese nuclear incident on US lands and populations. The NADP could also assist surveillance for biological, chemical, or radiological agents spread by terrorists.

NADP data is also important for food security and safety. Monitoring data on plant pathogens is used to inform decisions about cropping practices and pesticide applications and to assess the overall effectiveness of innovative technologies for reducing the impact of agriculture on the environment.

As an NRSP, some of the NADP's most important impacts are the journal articles that are produced using NADP data. The use of NADP data in multiple theses and dissertations demonstrates the educational role NRSP-3 and the NADP play. During the 2014 calendar year alone, 236 publications, including 23 dissertations and theses, used NADP data in some way.

Want to know more?

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National Research Support Projects support research by collecting, assembling, storing, and distributing materials, resources, and data; developing enabling technologies; and/or sharing facilities. NRSPs have a unique capacity for encouraging multidisciplinary, multistate collaboration and leveraging investments from far-ranging funding sources in order to meet stakeholder needs and tackle important issues facing U.S. agriculture, the environment and natural resources, food and nutrition, and family and rural community development. NRSPs are initiated by off-the-top funding drawn from the total federal Hatch Act allocation prior to formula distribution to state Agricultural Experiment Stations. Additional funds are provided by contracts and grants to participating scientists. In 2014, NRSP-3 was renewed through 2019.



<http://nadp.isws.illinois.edu>
nadp@isws.illinois.edu

Studies & Findings That Used NADP Data

Ecosystems

- In mid-latitude forests, nitrogen deposition has enabled species that are more nitrogen-efficient to out-compete native legumes
- In northern forests, atmospheric deposition increases correspond with decreases in biomass of fungi and microbial communities
- Accumulated rainwater is the primary source of water for bison

Agriculture

- Multiple researchers found correlations between ammonia, nitrogen, and phosphorous deposition with proximity to livestock operations
- Multiple researchers measured changes in atmospheric deposition due to litter amendments for poultry, diet changes for cattle, use of cover crops, crop rotation, and reduced chemical fertilizer use
- Researchers developed a new model of plant pathogen spore distribution

Air Quality

- Air pollution is a major factor in tree mortality in the eastern US
- Researchers improved an EPA air quality model with respect to ammonia

Climate Change

- Multiple researchers evaluated and predicted climate change impacts

NADP Website & Data Usage



In 2014, the number of users totaled
>37,000

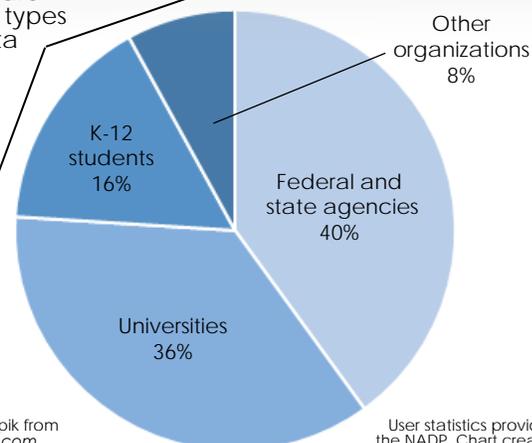


from
150+ countries
on every continent
except Antarctica



These users made
>27,000
data downloads

There are many types of data users



Icons by Freepik from www.flaticon.com. Creative Commons BY 3.0

User statistics provided by the NADP. Chart created by Sara Delheimer.

Genetic Considerations for Beef Cattle Production in Challenging Environments

S-1045 (2009-2014)

Cattle Producers Face Challenges in the South

Beef cattle production is an important part of southern economies. The southern U.S. accounts for over 42% of the nation's beef cattle inventory and almost 50% of the nation's beef producers. These producers face a variety of regional environmental challenges. Although the southern U.S. has abundant forage for much of the year, high heat and humidity conditions across the region can be stressful to cattle. Cattle diseases and pests, such as flies and ticks, that pervade the region can reduce cattle performance and burden producers with the cost of treating cattle for these maladies.

Cattle productivity, survival, and adaptability is partly influenced by genetics, and producers need updated genetic information about modern cattle types to be able to breed animals that are suitable for the region. Researchers also need to develop and test ways to identify and mark genes that are associated with valuable traits. In the past, few research entities in the southern region have had enough cattle or resources to effectively and independently conduct long-term genetic studies or to examine traits across an entire population of cattle.

Multistate Research Project Coordinates Genetic Research & Strategies to Improve Beef Production

In 2009, researchers formed multistate project S-1045 to leverage collaboration, resources, and knowledge to develop new cattle production and management tools and practices for the southern region. During the last five years, the group gathered and stored sources of DNA on over 2,500 cows and calves along with detailed pedigree and physical trait information. Using these resources, scientists examined genes that influence economically important traits in beef cattle. For instance, researchers looked at how hair coat traits, such as shedding, are related to growth and reproduction. Scientists also conducted studies to estimate the influence of genetic variation on susceptibility/resistance to disease in cattle managed on forage and compared the fertility of tropically adapted beef breeds and *Bos indicus* breeds.

S-1045's research activities and findings have provided genetic information and strategies that have been used to increase beef cattle productivity, improve animal welfare, and reduce production costs in the southern region.

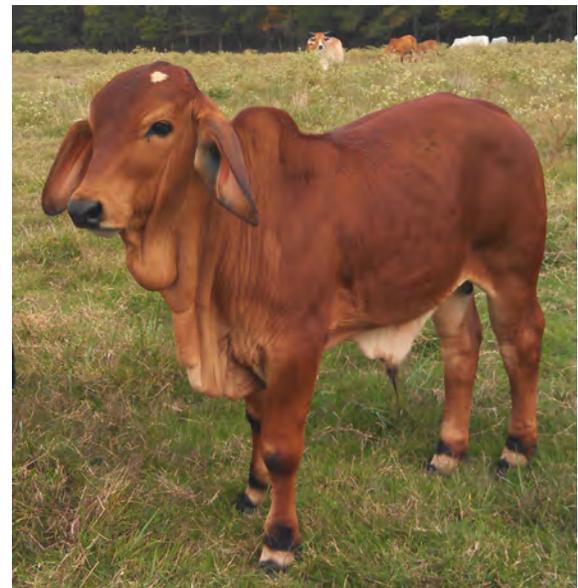
A DNA bank established by S-1045 serves as a useful resource for discovering important genes related to traits of economic importance, including meat tenderness, high fertility, and disease resistance. Multistate participation provided a larger number of data sources and records, allowing scientists to get a more complete, accurate picture of reproductive and survival traits among multiple populations of diverse breeds. Storing other information about steer behavior, health, immune responses, feed intake, and growth in conjunction with the DNA resources has made this dataset unique and has advanced opportunities for genomics-based animal health research.

Furthermore, with more thorough genetic information for cattle breeds and specific cattle family lines, scientists have been able to make more nuanced breeding recommendations to producers. Producers who followed these recommendations have had healthier cows, higher reproduction performance, higher calf survival, and reduced costs.

More precise measurements of genetic variation and susceptibility to Infectious Bovine Keratoconjunctivitis (IBK), Bovine Respiratory Disease Complex, and cattle ticks have been used by beef producers to identify animals that express resistance



Flies are a common pest of cattle in hot climates. Heel flies, horn flies, and stable flies can cause severe irritation and damage to the cattle hides and meat. Fly bites and burrowing to lay eggs can also result in significant blood loss, leading to anemia, paralysis, and disease transmission. Photo by Lauren Tucker/Flickr, Creative Commons License 2.0.



Bos indicus cattle are of south Asian origin and are often well adapted to hot, humid climates. Crossing these breeds with other breeds known for better meat quality or higher milk production can create cattle well suited for the southern U.S. and save producers money. Photo by Rhonda Vann, Mississippi State University.

to these maladies, enabling them to achieve higher herd productivity through breeding programs. Disease prevention through breeding has been a more cost-effective approach than pest and disease treatment methods.

- In Arkansas, researchers estimate that genetic resistance to IBK alone reduces producers' losses by \$30.00 per animal. With over 750,000 head of cattle in Arkansas, this could mean a total cost savings of \$7.9 million, not including money saved by avoiding treatment costs.
- Early vaccination of calves for bovine viral diarrhea (BVDV) is estimated to reduce the reported loss by \$4.85 per cow. Based on their studies and economic models, researchers estimate that a 10% reduction in the incidence of BVDV could be worth \$1.5 million to Arkansas producers.

Quantifying genetic variation of hair coat shedding and its influence on economically important traits has helped cattle producers in the southern region, as well as other tropical and sub-tropical regions, design and sustain successful breeding programs. Using S-1045's hair shedding scores in conjunction with growth and reproductive performance data, producers have been able to choose cattle that better suit their specific production environments and make improved breeding decisions. Knowing how to choose more adaptable cattle could enhance sustainable production options for producers and potentially increase current production by 10%.



A group of S-1045 researchers looked at how hair coat traits of Senepol cattle (above) are related to other production traits when the cattle are raised in tropical climates like the U.S. Virgin Islands. Photo by Bob Godfrey, University of the Virgin Islands.



Researchers participating in S-1045 work closely and meet regularly to share information and resources to address beef cattle production challenges in the southern U.S. Photo by Amber Starnes.

HIGHLIGHTED RESEARCH FINDINGS

Pests & Diseases

- Tick burden did not appear to have a significant influence on production traits of Senepol cattle in a tropical environment.
- Method for counting horn flies in beef cattle was reliable across multiple observers.
- Hematology showed large genetic variation in response to BVDV.
- In breeding programs, selecting for cattle with low tick loads can improve growth rate of calves until weaned.

Hair Coat

- Hair coat did not appear to have a significant influence on production traits of Senepol cattle in a tropical environment.
- In breeding programs, selecting for cattle that shed their winter hair coat faster can increase growth rate.

Managing Reproduction

- Differences in rainfall and forage quantity and quality in the spring compared to the fall in the U.S. Virgin Islands leads to spring calves being heavier than fall calves at weaning.

Want to know more?

The S-1045 project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1888) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. Additional funds were provided by contracts and grants to participating scientists. For more information, visit <http://saaesd.ncsu.edu>.

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List of Participating Institutions:

- University of Arkansas
- University of Florida
- Mississippi State University
- North Carolina State University
- Oklahoma State University
- Texas AgriLife Research
- University of the Virgin Islands

This Impact Summary was compiled and designed by Sara Delheimer.

Plant-Parasitic Nematode Management through Diagnostics & Host Resistance

S-1046 (2009-2014)

Plant-Parasitic Nematodes are a Widespread Threat to Crops in the Southern U.S.

Plant-parasitic nematodes are tiny worm-like animals that feed on plant hosts. They can also transfer viruses that weaken or kill the plant host. Plant-parasitic nematodes cause estimated yield losses of 10% to 60% annually. They are especially threatening to crop production in the southern U.S., where the warm climate and sandy soils provide an ideal environment for the pests. Cotton, peanut, soybean, turf, and many vegetable crops are among the most highly impacted.

Historically, nematode management has relied on the use of nematicides; however, many existing nematicides have been banned or greatly restricted due to environmental and human health concerns. In the last 30 years, only three new nematicides have been developed. Other nematode management options, like crop rotation and biological control, are difficult to practice effectively and have had limited success. Nematode-resistant crops are a promising strategy for sustainable management of these pests. Using resistant crops can improve yields and lower production costs by reducing losses to nematodes without expensive nematicide applications. However, as new nematode species are discovered, better ways to detect and correctly identify nematodes are needed. There is also increasing need for a wider variety of sources of genetic resistance to prevent outbreaks of more virulent races of nematodes. For example, the Bedford soybean was widely used for resistance to race 3 soybean cyst nematodes. This resistance was compromised in just one growing season as race 14 became more prevalent, overcoming the particular resistance genes in Bedford soybeans. Crops with multiple resistance genes could maintain resistance longer.

Multistate Research Project Develops New Tools to Detect Nematodes, Improves Crop Resistance to Ward off Infestations

In 2003, Multistate Research Project S-1046 formed to improve nematode management by developing new diagnostic tools and crop varieties with new sources of resistance to plant-parasitic nematodes. The multistate approach has allowed scientists to share resources and avoid duplicate studies during long-term crop breeding efforts. The multistate framework has also facilitated partnerships with industry and growers associations.

S-1046 researchers advanced a new molecular technique that has increased the accuracy of detecting and quantifying the presence of nematodes in soil. S-1046's characterizations of the diverse array of nematodes has made identifying economically important species easier and more certain. Earlier detection will help farmers take action against the pests before a serious and costly outbreak. For example, S-1046 scientists described a new species of root-knot nematode that is parasitizing bentgrass on popular golf courses in the mid-Atlantic states. Proper identification of this pest means golf course managers can target control strategies to quickly and effectively protect the courses from damage.

Groups of scientists from Alabama, Georgia, Mississippi, and Texas screened different collections of germplasm (the living genetic resources such as seeds or tissue maintained for breeding, preservation, and other research uses) for resistance to nematodes. The scientists identified and characterized the best sources of resistance to root-knot and reniform nematodes in peanut and cotton. Scientists also identified sorghum hybrids with good field tolerance to root-knot and lance nematodes and soybean varieties with resistance to root-knot nematodes. As a result, private sector seed companies have been able to develop new crop varieties with resistance to parasitic nematodes. S-1046 scientists also noted that specialty melons can



The top photo shows a carrot plant with root-knot nematode damage. Root-knot nematodes form knots, or galls, on plant roots (as shown above on cucumber roots). Galled roots have limited ability to absorb and transport water and nutrients to the rest of the plant, causing infected plants to wilt. Root-knot nematodes are particularly destructive because of their extensive host range--they are able to parasitize nearly every crop grown in the U.S. Photos courtesy of Don Dickson, University of Florida.

be successfully grafted on African horned cucumber rootstocks, which are highly resistant to root-knot nematodes. Alternative control methods like this are urgently needed to keep up with growing melon demand since methyl bromide, a broad-spectrum soil fumigant, was banned.

S-1046 also made significant advances in stacking genes (crossing plants that each have a different nematode resistance gene, and then identifying offspring possessing both of the desired genes) to increase resistance to root-knot nematodes. Stacking different sources of genetic resistance lowers the risk that a more virulent race of root-knot nematode will be able to take over. Increasing the durability of new crop varieties protects crop yields and profits while reducing the need for pesticides.

To proactively control emerging nematode species, researchers developed diagnostic tools for rapid identification of new nematode species, surveyed crops for the prevalence of these new nematodes, and tested resistant crops to make sure resistance extends to the new species. An online database was created to catalog newly described nematode species and their virulence.

S-1046 researchers also quantified how soil texture and irrigation affect yield losses caused by plant-parasitic nematodes. Using this information, the team designed new crop management tactics that work well when integrated with resistant crops. By ensuring that the nematode-resistant crops produced by U.S. farmers are compatible with changing cropping practices, production technologies, and environmental concerns, S-1046 is securing agricultural productivity now and in the future.

Want to know more?

The S-1046 project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1888) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. Additional funds were provided by contracts and grants to participating scientists. For more information, visit <http://saaesd.ncsu.edu>.

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List of Participating Institutions:

- University of Arkansas
- Auburn University
- Clemson University
- University of Florida
- Louisiana State University
- Louisiana Cooperative Extension
- University of Minnesota
- Mississippi State University
- University of Missouri
- North Carolina State University
- University of Tennessee
- Texas AgriLife Research
- USDA-ARS, Georgia
- USDA-ARS, Mississippi
- Virginia Polytechnic Institute and State University

This Impact Summary was compiled and designed by Sara Delheimer.



S-1046 test fields showed improved growth of cotton lines with resistance to reniform nematodes compared to susceptible lines at mid-season and harvest. Photos by Kathy Lawrence, Auburn University.



In S-1046 test fields, rows of cotton showed that nematicides enhanced growth of both resistant and susceptible cotton genotypes. Photo by Drew Schrimsher.



Sweetpotato Collaborators Conference

This project has shared information and technology that improved sweetpotato yield, quality, and food safety, thus reducing grower costs and increasing consumer satisfaction.

Who cares and why?

Sweetpotatoes are a major crop in the U.S., especially southern states. Farmers harvested 116,900 acres with a production value of \$478,308,000 in 2010, but they still face many production and post-harvest challenges. In order to maintain sweetpotato production, growers need to know which varieties grow best in the conditions on their farms as well as how to best manage insects, weeds, and diseases that can damage crops and raise costs. Coordinated, comprehensive research and outreach are needed to help sweetpotato producers navigate and resolve complex production challenges. After harvest, sweetpotatoes must be properly stored, packed, and marketed so that a supply of safe, nutritious produce is available for consumers.



What has the project done so far?

Since this project started in 1939, SERA-005 has provided vital support for the sweetpotato industry by exchanging information and technology related to sweetpotato production and post-harvest concerns. Diverse participation in the project has included scientists and Extension professionals from universities and organizations around the world, representatives from government and industry groups, and sweet potato growers. With over 1,000 peer-reviewed publications in addition to Extension materials and programs, the SERA-005 group has been a valuable resource for the global research community and sweetpotato growers and consumers. The group's main focus has been evaluating and releasing new sweetpotato varieties, many of which have been adopted worldwide. By taking into account the effects of soil type on sweetpotato shape and yield, the group has been able to make variety selection decisions that address regional needs. So far, 94 varieties have been released. Pathologists and breeders have worked together to identify the causes of many sweetpotato diseases and to develop varieties with resistance to these diseases. This work has helped launch virus-tested seed programs in many states. In addition, the group has designed successful management strategies for pests like the sweetpotato weevil and provided growers with effective registered pesticides. Scientists have also helped growers understand the importance of water availability and demonstrated proper temperature for storage root development and yield. Research on post-harvest diseases has made it possible to market sweetpotatoes year-round and could reduce use of fungicides on packing lines. The Collaborators group has also recently partnered with the industry to develop food safety programming.



Sweetpotatoes are grown across the U.S., but certain varieties are better adapted to environmental conditions in different regions. SERA-005 has been instrumental in providing the best varieties to farmers and helping them understand the importance of soil type, water availability, and storage temperature on yield and quality. Top photo by Craig Yencho, North Carolina State University. Bottom photo by advencap, Flickr.

Impact Statements

Advanced scientific research by fostering collaboration.

Released 94 new sweetpotato varieties, which have been adopted worldwide and have led to yields that are better than 20% of former standard varieties.

Cut growers' costs by breeding sweetpotatoes with valuable qualities like disease resistance and tougher skin.

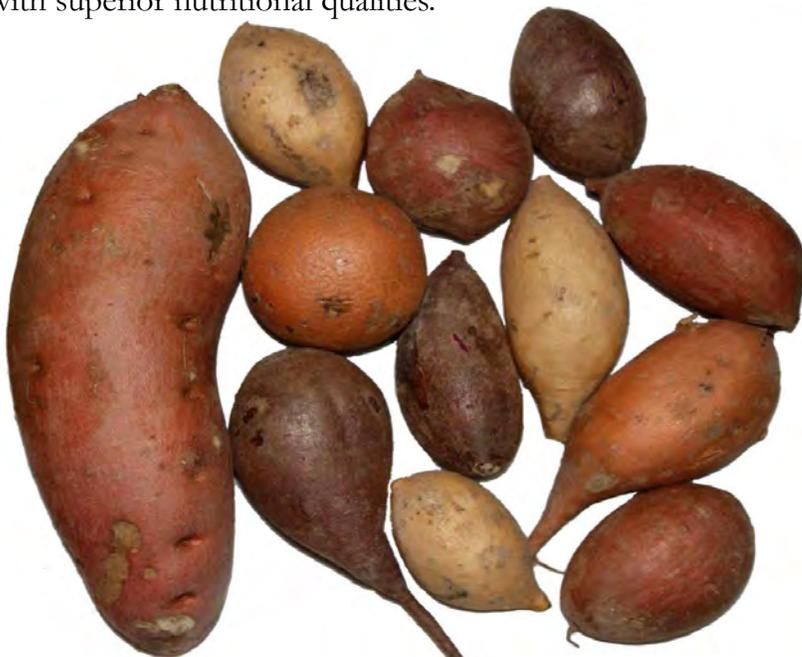
Provided research-based information and training, which has led more sweetpotato growers to adopt technologies and practices that improve the yield, quality, and food safety of their produce.



SERA-005 members have served as technical leads for the Bill and Melinda Gates Foundation, which sponsors local agricultural programs across Africa. Participating in one of these programs, the Tanzanian women above learned about sweetpotatoes bred specifically to thrive in sub-Saharan Africa. The women also learned about soil irrigation, crop multiplication, and how to get crops to market. In this way, skills and knowledge that are rooted in SERA-005 research and outreach are helping communities around the world. Photo © Bill and Melinda Gates Foundation.

What research is needed?

In order for the sweetpotato industry to adapt to production and post-harvest challenges, continued sharing of research-based information among a diverse community of scientists, Extension specialists, and industry members is necessary. Researchers need to continue to address sweetpotato insects, weeds, and diseases, especially end rot, and explore effective ways to preserve the food quality and safety of sweetpotato products for consumers. Future research also needs to address the demand for better sweetpotato varieties specifically for processing industries and new products with superior nutritional qualities.



SERA-005 breeding research has led to a wide range of sweetpotato varieties that farmers can select to grow. Photo by Craig Yencho, North Carolina State University.

Want to know more?

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This project was supported by the Multistate Research Fund (MRF) established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1888) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. For more information, visit <http://saaesd.ncsu.edu/>.

Compiled and designed by Sara Delheimer

Marketing, Trade & Management of Aquaculture & Fishery Resources

W-2004 (2009-2014)

Fisheries & Aquaculture Face Management and Marketing Challenges

Salmon, pollock, shrimp, catfish, and other fishery and aquaculture enterprises in the US provide a significant source of protein, economic activity, and recreation; however, both traditional capture fisheries and aquaculture (cultivating fish on “farms”) face numerous challenges. Harvest limitations, new regulatory systems, changing marketing landscapes, increasing competition from imported seafood, and depreciating infrastructure are challenges that demand innovative industry practices. Furthermore, because they are biologically-based and often located in coastal zones, fisheries are susceptible to shocks from environmental events like hurricanes and oil spills. To meet these challenges, producers and policymakers need reliable information concerning the economic implications of regulatory actions, changes in market and environmental conditions, changing consumer preferences, advances in harvesting methods and technology, and changing institutional arrangements in the supply chain.

Multistate Research Project Boosts Economic Sustainability of Fisheries & Aquaculture

In 2009, Multistate Research Project W-2004 formed to coordinate research on and extension of improved management, trade, and marketing strategies for aquaculture and capture fisheries.

- W-2004 has started to address the problem of economic illiteracy in the fishing industry and regulatory processes, helping producers and policymakers make more sustainable decisions. For example, researchers quantified both the biological and economic impacts of sea lice on farmed salmon, and policymakers used this information to set appropriate thresholds at which farms must use chemical treatment or culling to control infestations. Research-based thresholds better protect against costly outbreaks and potential transmission to nearby wild salmon populations.
- W-2004 illuminated ways to structure harvest quotas and incentives to minimize bycatch and wasteful at-sea discards, helping fishers avoid costly penalties and protecting fisheries from overexploitation.
- W-2004’s recommendations for effective marketing practices are being adopted, enhancing producer welfare and boosting the competitiveness of the US fishing and aquaculture industries. In particular, the industry is using data on consumer preferences to market farm-raised and wild-caught seafood products to a broader variety of consumers.



Consumer preferences surveys conducted by W-2004 indicated that locally grown seafood positively influences willingness-to-pay for products, and price premiums for wild-caught seafood are acceptable to people who grew up in coastal areas. USDA-ARS photo by Peggy Greb.

Research & Extension Activities

Consumer Preferences & Marketing

Over the past five years, W-2004 investigated seafood product marketing. For example, researchers examined labeling requirements for product safety and traceability and the impacts of eco-labeling on price premiums. The eco-labeling analyses are being used by the industry and policymakers to determine if the benefits of labeling outweigh the costs. Researchers also examined the relationship between consumer preferences and information about health risks and benefits. Results showed a considerable lack of unbiased knowledge of seafood attributes, making it difficult for consumers to balance health risks and benefits. W-2004 members in Hawaii and Kentucky conducted state-wide surveys, which indicated that locally grown seafood increases willingness-to-pay, and price premiums for wild-caught seafood are acceptable to people who grew up in coastal areas. In addition to these studies and surveys, researchers developed new tools and techniques for analyzing seafood markets and demand, including decision support tools and ways to use scanner data.

Fishery & Aquaculture Management

W-2004 also examined the economic and sociological factors that influence fishery management and generated ideas to increase the efficiency and stability of fisheries. Researchers explored regulatory approaches that provide fishers with market-based incentives to target their catch and avoid bycatch of non-target, non-marketed species, including sea turtles and sea birds. In addition, research showed that allowing fishers to trade individual harvest quotas can minimize the number of fish discarded at sea. Related research evaluated the behavior of fishers under different management schemes and documented the emergence of different kinds of management regimes over time.

Researchers also evaluated the impact of the regulatory environment on the development of aquaculture in the US. Using data from an online survey, W-2004 researchers compared the perceptions of aquaculture stakeholders in the US and Norway. Results provided useful information for US aquaculture policymakers, regulators, and stakeholders regarding how policies, practices, and education could change perceptions of aquaculture stakeholders and the future of US aquaculture.

Over the course of the project, W-2004 researchers identified case studies of commercial success and innovation in the global fishery and aquaculture industries. These case studies informed the development of performance-based indicators for estimating long-term wealth generation and sustainability in specific fisheries. These indicators are being used by federal and international agencies (e.g., the World Bank) to evaluate and prioritize fishery management projects.

Outreach

The group delivered research results to stakeholders through scientific conferences, book chapters, reports, databases, and Extension and outreach programs. In addition, the group expanded the development and use of online fisheries economics and management courses. Online materials make it easier for fishers across wide geographic distance to access up-to-date information and training resources. W-2004 also educated scientists and industry representatives on future training and employment opportunities for fisheries economists.

Want to know more?

This project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1887) to encourage and enhance multistate, multidisciplinary research on critical issues. Additional funds were provided by contracts and grants to participating researchers. For more information, visit <http://www.waaesd.org>.

Administrative Advisor: Larry Curtis, Oregon State University

Participating Institutions:

University of Alaska, Anchorage
Auburn University
University of California, Davis
University of Connecticut, Storrs
Clark University
University of Florida
University of Hawaii
Iowa State University
Louisiana State University
Mississippi State University
University of Missouri
Oregon State University
Purdue University
University of Rhode Island
University of Stavanger
National Oceanic and Atmospheric Administration (NOAA)
Northeast Fisheries Science Center/NOAA
Pacific Islands Fisheries Science Center/NOAA
World Bank

Impact Statement compiled by Sara Delheimer.

Multistate Research Project | Impact Summary



W-2004 researchers identified regulatory approaches that provide fishers with market-based incentives to avoid overharvesting and minimize bycatch. Photo by Bart Eaton.



In fisheries systems, extreme weather events, like hurricanes, and long-term changes in precipitation, such as droughts, can have profound impacts on ecosystems and the sustainability of fisheries. During Hurricane Irene, high flood waters breached some fish rearing pools at White River National Fish Hatchery, leaving some fish stranded among the sediment brought in by the flood waters. W-2004's economic models incorporate environmental constraints and impacts to better inform fishery managers and policymakers' efforts to protect the fisheries, the fishers, and the communities and consumers that depend on them. USFWS photo by Ann Froschauer.

Microirrigation for Sustainable Water Use

W-2128 (2009-2014)

Irrigation Strains Western Water Supplies

The West is home to some of the fastest growing communities in the nation, and these growing communities are putting additional strain on already overdrawn water supplies in the region. A major user of Western water is irrigated farmland needed to feed a growing world population. Adequate irrigation is necessary for good crop yields and quality, particularly in semi-arid and arid regions, but excessive irrigation can damage crops, and excess water can carry pollutants like chemicals and sediment into surface and groundwater.

Conventional irrigation systems that apply high volumes of water over wide areas can lose a lot of water through runoff, wind, or evaporation, and they often over or under-water plants. A more efficient option—microirrigation—delivers small quantities of water as needed above or below the soil surface to plants through emitters spaced along a water line. Microirrigation (MI) systems could help farmers reduce their draws on water supplies, but perceptions of high cost, poor reliability, tedious maintenance, and lack of support or guidance have made farmers hesitant to adopt the technology. Without information or recommendations for their particular farm conditions and crops, farmers have also struggled with irrigation scheduling, or determining when and how much water to apply, which is crucial for maximum water savings.

Multistate Research Project Makes Microirrigation More Sustainable, Saves Water & Money

In 1972, researchers formed Multistate Research Project W-2128 to coordinate MI research across the U.S. Over the last five years, the group has made remarkable improvements to MI systems that have had huge environmental, economic, and societal impacts.

Improved Design

Recent research has influenced MI system design and manufacturing, leading to equipment that is easier to install, more durable, and more precise. These improvements have reduced the frequency and severity of MI system failures, cutting maintenance costs and ensuring reliable irrigation for crops.

Educated Farmers, Increased MI Use

Engaging with growers, W-2128 members have made certain that new MI technologies are appropriate for varying crops, soils, climates, and farmer needs and skills. Such extensive and robust outreach efforts have countered the perception that MI is difficult. In turn, more farmers—even farmers of lower-value crops—have increased adoption and successful use of MI.

Saving Water Saves Money

Farmers who have adopted the tools and methods tested and recommended by W-2128 have saved water and money. Cost savings have come largely from using improved MI systems to deliver just the right amount of water at just the right time. For example, Idaho farmers have saved 10% or more on labor and water pumping costs by following recommendations to measure soil water levels daily at multiple depths to know when soils are dry. W-2128 technology and tips were also critical in mitigating Texas' record-breaking drought in 2011. Farmers have seen additional cost savings by using these tools and methods to delay the start of irrigation, saving water for later in the season.



In microirrigation systems, water evaporation is kept to a minimum because water is delivered to the soil near the plant's roots, not sprayed into the air or over large, exposed areas. Water is supplied from a main line to separate smaller tubes that run along each row of plants. These tubes emit water at a very slow rate near the base of each plant. Computers and timers allow farmers to fine-tune the watering. Top photo by Ryo Chijiwa, Flickr. Bottom photo by Freddie Lamm/KSU.

Research & Extension Highlights

For the last five years, agricultural engineers, plant and soil scientists, and economists participating in W-2128 have conducted a wide variety of studies and outreach efforts. Here are a few highlights that led to impressive impacts.

University of Idaho: demonstrated better crop yields with microirrigation than center pivot irrigation (32 tons per acre versus 28 tons per acre).

New Mexico State University (NMSU): tested and compared several models of drip tubing and emitters that can be used for inexpensive, low pressure microirrigation suitable for small farms.

University of California, Davis: designed a new tensiometer to monitor soil water potential below the root zone in real-time, 24/7.

USDA-ARS: designed infrared thermometers, which can be used to measure plant canopy temperature in real-time and developed irrigation scheduling strategies based on these temperatures.

Iowa State University: showed that using fewer sensors can still provide cost effective, detailed maps of soil moisture content if the sensors are placed strategically.

University of California, Davis: developed new wireless data logging systems for perennial crops. Growers do not have to remove or disconnect sensors, wires, or data loggers during yearly harvests.

Oregon State University: calibrated soil water sensors to improve the precision of irrigation scheduling.

More Water for More Farmers

By conserving water, newly adopted tools and practices have made it possible to irrigate additional land—particularly land not suitable for other irrigation technology. For example, MI systems could help farmers in Puerto Rico grow taro in dry conditions. This ability would allow farmers to establish taro on a commercial scale and replace imports and boost the economy. W-2128 research and extension efforts have also helped under-served clientele—like small-acreage farmers and low-input producers—take advantage of MI.

Improved Crop Yields & Quality

Farmers have seen improved crop yield and quality. In the U.S. Virgin Islands, drip irrigation has been very beneficial for the farming community and has produced marketable vegetables in a variety of trials, including lettuce, kale, and watermelon varieties. Furthermore, improved sensors help farmer detect irrigation problems early and correct them quickly, cutting costs due to crop losses.

Reduced Pollution & Health Risks

Adoption of MI technologies promoted by W-2128 has reduced risk of negative environmental and water quality effects. Applying agrochemicals precisely with MI has reduced the amount of agrochemicals that leach into groundwater or runoff into streams and lakes, limiting human exposure. For example, better use of irrigation systems and irrigation criteria in Oregon has increased onion yields and decreased groundwater nitrate contamination.

Using Non-Potable Water Conserves Freshwater

Research and extension have promoted the use of non-potable water resources in MI systems, saving freshwater for higher-value domestic and industrial uses. For example, W-2128 has adapted MI technologies to use recycled waters from confined animal feeding operations.

Restored Land

Researchers have also shown that MI is a viable strategy for establishing and maintaining trees, shrubs, and grasses on disturbed lands sites, including uranium mill sites on the Navajo Nation and former petroleum refineries. Replanting these sites reduces erosion and airborne dust, limiting threats to environmental and human health.

Want to know more?

Helpful websites:

<http://www.cropinfo.net/MI/>

<http://micromaintain.ucanr.edu>

<http://www.crec.ifas.ufl.edu/extension/irrigation/>

The W-2128 project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1888) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. Additional funds were provided by contracts and grants to participating scientists. For more information, visit <http://www.waaesd.org/>.

Institutions from the following states contributed data on specific crops: AL (cotton, corn soybean, wheat), CA (almond, pecan, grape), FL (citrus, blueberry, strawberry), GA (cotton, corn, peanut), HI (sweet corn, vegetables), ID (turf, alfalfa, sugar beets), KS (corn, grain sorghum, sunflower, alfalfa, soybean), NM (pecan, poplar, tomato, onion, pepper, squash), NY (apple, grape), OR (onion, poplar, potato), Puerto Rico (citrus, avocado), TX (corn, cotton, sorghum, soybean).

This Impact Summary was compiled and designed by Sara Delheimer.

NMSU: determined how much to adjust irrigation timing and amount based on climate and plant canopy factors.

NMSU: determined irrigation scheduling for drought-tolerant landscape plants and vegetable crops.

Cornell University: measured evapotranspiration rates for apples and grapes in cool, humid climates and used this data to create an automated online system that New York growers can use to optimize irrigation.

Texas AgriLife Research: developed engineering guidelines for permanently installed MI systems that function well in the cracking, heavy clay loam soil of the Texas High Plains.

NMSU: developed a model of how soil temperature and moisture affect the life cycle of *Phytophthora capsici* and how the disease develops on chile and bell peppers.

NMSU: showed that shifting from furrow irrigation to drip irrigation can lower water inputs and the amount of nitrogen compounds that leach into the environment.

NMSU: tested and recommended the 2D model for scheduling MI for shallow-rooted crops to decrease pollution of groundwater.

W-2128 joint effort: developed guidelines for MI systems that irrigate with low quality water, including recommendations for using waters from human sources.

Colorado State University: high salinity groundwater can be used in MI systems to grow muskmelons without excessive harm to the crop or soil.

NMSU: initiated a phytoremediation project using MI to establish tree and shrub species at the former site of a petroleum refinery. Studies also showed that gravity-fed drip irrigation can be a viable strategy for establishing plantings in remote areas such as the sites of former uranium mills on the Navajo Nation.

University of Arizona: promoted using smartphone technology to help farmers, extension specialists, and scientists communicate, share data, and make good MI decisions in real time without traveling long distances.

Kansas State University: identified key barriers to increasing MI adoption, including rodent damage and perceived performance uncertainties.

W-2128 joint effort: shared research findings and recommendations with a variety of audiences via outreach and extension activities. W-2128 members held 145 outreach events with growers each year since 2009. In addition, they coordinated and presented technical sessions on MI scheduling at the 2009, 2012, and 2013 technical conference of the Irrigation Association. They also created websites to share guidelines and software and published numerous books and articles.



NMSU researchers determined that hybrid poplar trees are well-adapted to MI in the Four Corners region. These trees are being planted to remediate an abandoned oil refinery site. Photo by Mick O'Neill/NMSU.

Soil-Based Use of Residuals, Wastewater & Reclaimed Water

W-2170 (2009-2014)

Reusing Waste Addresses Many Issues, but Major Obstacles Exist



Biosolids can be applied to farmland as a substitute for fertilizer. City of Geneva photo.



Aerial view of Stickney Wastewater Treatment Plant. US Army Corps of Engineers photo.

Millions of tons of municipal, agricultural, and industrial solid waste are discarded each year in the U.S. Often, these solid wastes are disposed of in landfills or incinerated, which is costly to the industries and the public. Reusing solid wastes as soil substitutes, soil additives, or fertilizers could cut disposal costs and reduce landfill volume as well as help restore disturbed land and boost crop productivity. Wastewater (degraded water, stormwater, irrigation return flow, graywater, and effluents from livestock operations) can be reused in lieu of freshwater extractions—a popular option as water shortages loom. Soil can help treat reclaimed water by absorbing some of the nutrients before they have a chance to runoff into nearby bodies of water. Still, in 2009, less than 10% of treated wastewaters were reused.

The lack of standardized regulations for reusing wastes has been a major obstacle, particularly with concerns that wastes contain potential contaminants, including excess nitrogen, phosphorous, pesticides, industrial chemicals, and trace pharmaceuticals. More research is needed to determine the persistence of these compounds after waste is applied to soil and the potential threats they pose to air, water, and soil quality, or exposed plants, livestock, wildlife, and humans. The bioavailability of potential contaminants varies with different waste processing technologies, soil types, climates, and land management practices. In order to reuse wastes safely, practical scientific knowledge is needed to determine if and how waste can be used in a cost-effective and environmentally friendly manner in certain areas.

Multistate Research & Extension Project Yields Safer Waste Reuse Policies and Practices

Multistate Research Project W-2170 has made considerable advancements in understanding how to safely and economically reuse wastes. Over the last five years, researchers conducted field experiments, greenhouse studies, and laboratory tests with different wastes in varying conditions and developed new methods and tools to help evaluate the short- and long-term effects of applying wastes to soils.

W-2170 researchers identified processes that reduce contaminants in wastes, so that they can be reused safely.

- Pre-tilling soil prior to applying liquid wastes or manure reduces runoff of many contaminants into nearby surface and groundwater.
- Adding compost and biosolids (treated sewage sludge) to soils reduces potential of transferring contaminants like lead and arsenic to humans via vegetable consumption and soil ingestion.
- A new process for composting biosolids has resulted in an odor-free product that will have greater public acceptance for urban use.

W-2170's research has made it possible to develop science-based regulations and policies for reusing wastes.

- These regulations and policies have been used by a range of stakeholders, including municipal wastewater treatment plant operators, farmers, industries in charge of site remediation, and project managers from US EPA, Natural Resources Conservation Service, the Virginia Department of Environmental Quality, and Minnesota Pollution Control Agency, among others.
- New rules for setting limits on contaminants now require bioavailability assessments, which allows safer, more accurate limits.
- Regulations and standards have made it easier for industries to get the proper permitting and safely institute reuse processes that make them more competitive and sustainable.
- A testing program for soil amendments made from industrial by-products resulted in eight new materials being recommended for labeling by the Virginia Department of Agriculture and Consumer Services in 2012. Receiving an official state label has economic and public relations benefits for industries. The testing program has also rejected products that pose risks to soil and water quality.

Increased adoption of waste reuse policies influenced by W-2170 has reduced landfill waste and saved on disposal costs.

- Annually diverting one million tons of spent foundry sand from landfills would realize annual savings of \$30,000,000 by the foundry industry.
- Workshops and demonstrations promoted diversion of unusable food to animal feed or compost, thus reducing the disposal of such waste to landfills or incinerators.
- The Virginia Department of Environmental Quality accepted a new screening system developed by Virginia Tech researchers to identify reusable dredge sediments. This system is unique to the US and should lead to a major expansion of beneficial reuse of dredge sediments, which will decrease the cost of sediment management for the public taxpayer and lead to substantial income streams and improved soil productivity for receiving landowners.

Waste reuse policies and practices can lower waste disposal costs, reduce freshwater extraction, improve soil quality, and scale back use of agrochemicals. Reusing waste allows existing industries and agriculture to be more sustainable and opens the door for new industries and jobs.

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Increased adoption of waste reused as substitute fertilizers and soil amendments has improved soil quality and improved plant yields, especially in drought.

- Farming communities have successfully adopted the use of biosolids and food waste compost to alleviate soil acidity. Adding these wastes to soils to solve soil acidity problems that plague many regions in the developing world.
- Biosolids wastewater contains a lot of phosphorous—an essential nutrient for crops, and reusing it on farmland can help farmers improve phosphorous-poor soils and provide wastewater treatment plant operators with a viable option for recycling phosphorous.
- Applying biosolids to fields can increase crop yields more than synthetic fertilizers because they promote microorganisms that help protect plants against drought stress.

Reusing waste as substitute fertilizers and soil amendments has also reduced phosphorous leaching and runoff.

- Using drinking water treatment residuals (DWTR) to absorb excess phosphorous reduces leaching and runoff from agricultural land. DWTR with high iron and aluminum concentrations especially reduce the solubility of phosphorous—more than either commercial fertilizers or animal manures. Methods generated by W-2170 for applying DWTR make this promising water quality protection technology a practical option.

W-2170 developed management practices for minimizing greenhouse gas emissions when reusing wastes to amend soils.

- Long-term application—or one high application—of compost or biosolids to soils in the Mid-Atlantic region can accelerate soil carbon accumulation and increase soil carbon concentrations while also improving soil physical properties that enhance plant productivity.

W-2170 has provided options for cost-effective land reclamation through reuse of wastes.

- Use of biosolids to rehabilitate contaminated ecosystems has been included as an option for a number of EPA Superfund National Priority List sites.
- W-2170 developed gardening initiatives for brownfields that involve amending soils with wastes to reduce contaminants in the soil. This work is allowing brownfields to be turned into community gardens that produce crops without potentially adverse health effects to the grower or the consumer.
- Commonly used, inexpensive, and widely available agricultural soil tests can be used to screen lead-enriched urban soil. Rapid and affordable lead assessment will allow city planners, communities, and other groups to convert vacant land into urban farms, gardens, parks, playgrounds, and other common areas.
- Virginia's adoption of the W-2170's proposed practices for using biosolids to restore mined land has resulted in changes in mine operations and closure procedures and lower cost options for disturbed land reclamation.
- Using high amounts of biosolids and compost to reconstruct and restore prime farmland following mineral sands mining decreases the cost of mining, increases landowner royalty return, and provides optimal soil productivity for future crops with minimal risks of nitrogen leaching to groundwater.
- Using W-2170 research, Virginia Tech and Iluka Resources, Inc. successfully petitioned their state regulatory agency for a waiver of requirements to save and return topsoil on their mineral sands mines in eastern Virginia. This permit amendment will add millions of dollars to the company, landowners via royalty return, local counties via severance tax, and the state via increased corporate tax base. Iluka Resources, Inc. was awarded the National Mined Land Reclamation Award by the Interstate Mining Compact Commission, and W-2170 was credited as the underpinning source of technology.
- The first use of trading credits to pay for poultry manure transport from farm to mine reclamation site occurred in Pennsylvania as a result of W-2170's research on mine land reclamation.

W-2170 advancements have led to emerging markets, industries, and jobs.

- Spent foundry sand in Ohio can be used as a component of manufactured soils, allowing foundries to create start-up industries and jobs focused on production and marketing of spent foundry sand soil blend materials to the public.

Want to know more?

W-2170 was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1888) to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. For more information, visit <http://waaesd.org>

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New Mexico State University
Ohio State University

Oklahoma State University
Pennsylvania State University
Purdue University
Virginia Polytechnic Institute and State University
University of Washington
Washington State University
Agriculture & Agri-Food Canada
Metropolitan Water Reclamation District of Greater Chicago
Texas AgriLife Research
US Environmental Protection Agency



Research plots for the Maryland Port Administration Cox Creek dredge study will determine if dredge sediment is suitable for reuse.

This Impact Summary was compiled and designed by Sara Delheimer.

Manipulating Cells & Embryos for the Improvement of Livestock

W-2171 (2009-2014)

Genetically Improved Livestock Offer Benefits, but Technology is Inefficient

Although scientists have made significant strides in the production of genetically improved livestock, the basic biological mechanisms underlying the techniques used to produce these unique animals are not well understood. Furthermore, most of the tools and techniques remain extremely inefficient. These tools and techniques must be improved in order to benefit from the advantages of genetically manipulated farm animals, such as desirable, healthier, or value-added foodstuffs and lower natural resource use consumption by livestock operations. New strategies will help keep US animal agriculture competitive in the global market.

Multistate Research Project Increases Efficiency of Key Processes in Genetic Manipulation of Livestock

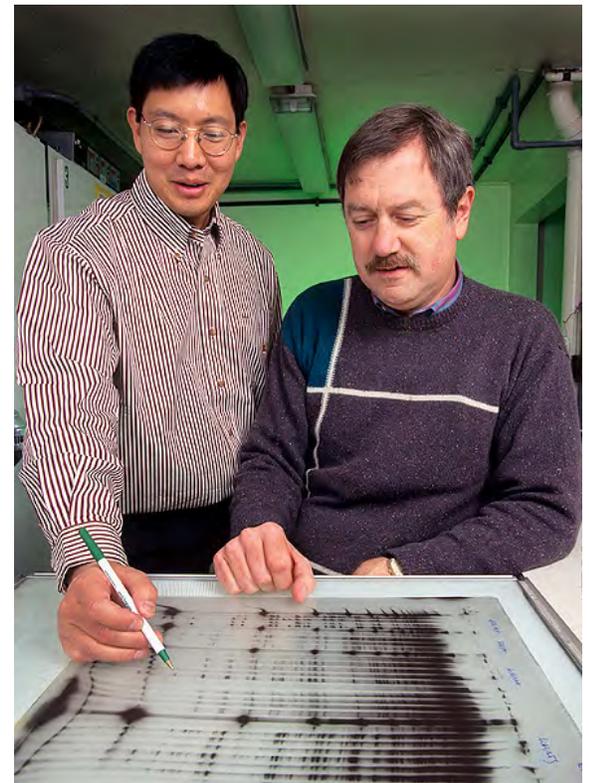
In 2009, Multistate Research Project W-2171 formed to provide research and extension to increase the efficiency of egg cell, sperm cell, and embryonic manipulation—the key to genetically improved livestock. Over the past five years, researchers gained better understanding of fundamental physiological processes, in particular, the underlying mechanisms of gamete development, fertilization, placenta function, embryo development, and other aspects of reproductive performance. Advances in the efficiency of producing animals with manipulated genomes, along with approved mechanisms and regulations, are paving the way for more widespread adoption of assisted reproductive technologies and genetically improved livestock.

Improving livestock and production efficiency is important for meeting food demands associated with growing human population. In addition, consumers could benefit from reduced food prices associated with increased efficiency of livestock production as well as enhanced food products for human health. Many of the technological advances of W-2171 may also be used as models for biomedical applications that could impact human wellbeing. Furthermore, genetically improved livestock could make it possible for livestock systems to use fewer natural resources and produce less waste, thus reducing the environmental impacts of livestock production.

Livestock producers will benefit from increased profits as a result of improved animal performance, value-added products, and better product consistency associated with genetically improved livestock. W-2171's advances are making it more affordable for producers to use genetic manipulation processes and technology. For example, newly identified genetic markers can be used to predict bull fertility, resulting in significant cost savings for producers. In addition, new ways to identify or predict a skewed sex ratio in semen may lead to a practical, cost effective method to control the sex of livestock offspring. Improvements to semen storage procedures have enhanced the efficiency and use of artificial insemination. Furthermore, newly identified genetic markers of important traits will help create animals with increased milk and meat production as well as disease resistance. Improvements to *in vitro* embryo production and fertilization processes have reduced early embryo and fetal mortality.



Scientists prepare to artificially inseminate a ewe. Improved technology and procedures are making it easier for producers to perform artificial insemination on their farms. USDA-ARS photo by Stephen Ausmus.



Scientists examine genetic marker results to enable more efficient isolation of important genes from the chicken genome. USDA-ARS photo by Peggy Greb.

Research & Extension Activities

Researchers found that the glutaredoxin pathway plays a critical role in egg cell development, helping researchers manipulate culture conditions to make egg cells more viable during *in vitro* fertilization (in which an egg is fertilized in a laboratory before being implanted into the prospective mother). In addition, the ability to use a simple chemical cysteamine as a substitute for expensive and cumbersome systems to lower oxygen concentrations could help keep embryos viable in many situations. From their studies, researchers now have a better understanding of embryo development and insights into implantation failure and early embryonic loss. Novel gene targeting approaches have provided a better understanding of placenta formation and function, a major part of embryo development and reproductive efficiency in animals.

Other researchers focused on the genetic mechanisms regulating male fertility. Researchers also demonstrated that semen remains viable after long-term cryopreservation; however, one study showed that stallion sperm respond differently to cryopreservation than semen from male donkeys.

Using this information, scientists refined methods and protocols for producing genetically improved animals. For example, they improved the technology for generating embryonic stem cells. Embryonic stem cells are important in genetic modification for disease resistance and other special traits. Researchers were also able to improve methods of *in vitro* embryo production. New technology enables the automation of techniques that produce large numbers of embryos *in vitro*. Improving *in vitro* egg cell maturation conditions will result in improved developmental capacity of *in vitro* embryos.

Want to know more?

W-2171 was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act (an amendment to the Hatch Act of 1887) to encourage and enhance multistate, multidisciplinary research on critical issues. Additional funds were provided by contracts and grants to participating researchers. In 2015, the project was renewed for another five year cycle under project number W-3171. For more information, visit <http://waaesd.org>.

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University of Georgia
University of Illinois
Iowa State University
Louisiana State University
University of Maryland
Michigan State University
Mississippi State University
University of Missouri
Montana State University
University of Nebraska
North Carolina State University
Oregon State University
Purdue University
Utah State University
West Virginia University



Scientists hope to find the genetic basis of disease resistance in pigs through gene mapping studies. USDA-ARS photo by Scott Bauer.

Managing Invasive Weeds in Wheat

WERA-77 (2009-2014)

Invasive Weeds Threaten Winter Wheat Yield & Quality

Invasive weeds infest more than 20 million acres of winter wheat in the western US, costing growers over \$500 million in yield losses each year. Dense infestations of weeds can result in complete crop failure. Smaller weed populations decrease wheat yields and increase the amount of weed seeds and stems that must be cleaned from harvested wheat grain. Weeds can also interact with viruses and other pests and have complex, synergistic impacts on grain yields and quality. Furthermore, many weeds are developing resistance to herbicides, requiring higher and/or more frequent applications, which can raise production costs, injure wheat plants, and pose threats to environmental and human health. Many weeds are difficult to manage. Thorough, up-to-date information about weed biology, ecology, and genetics is required to develop best management practices that offer integrated control.



With rolling hills and deep soils, the Palouse region in the northwestern US is a major agricultural area and a leading producer of wheat. USDA-ARS photo.

Multistate Research Project Improves Weed Control & Wheat Production

Multistate Research and Extension Project WERA-77 formed to find sustainable, economical ways to manage invasive weeds in wheat. Coordinating research and extension efforts across the region has facilitated rapid transmission of new knowledge and promising technologies to wheat growers. In particular, the project has provided the tools and information for quicker, more accurate identification of weed species. Faster identification has led to timely, targeted herbicide applications that prevent serious, costly outbreaks. Data from research trials have also been used to support labeling of herbicides for use in diverse wheat production systems. Continued education has encouraged more wheat growers to carefully manage herbicide use so that the onset of herbicide resistance in weed species is delayed as long as possible. New herbicides and application guidelines have helped growers control invasive weeds efficiently and avoid wheat injury and yield reductions. Additionally, because of WERA-77 trials and demonstrations, farmers are aware of effective ecological approaches to managing weeds. For example, WERA-77 studies showed that the combination of taller wheat varieties and increased seeding rates can be a viable and simple way to reduce weed seed production. WERA-77 studies also improved and expanded the use of winter canola as a crop rotation that improves weed control in wheat. For the 2011-2012 growing season, a record level of around 200,000 acres of winter canola were planted. All in all, WERA-77's efforts have helped maintain the competitiveness of wheat production in western states.



Mayweed chamomile, a common weed in the western US, often grows in winter wheat fields. Photo by Andreas Krappweis. RGBStock.com License.

Research Activities

Researchers conducted long-term field experiments and analyzed genes to identify wheat varieties with higher tolerance to both weeds and the herbicides used to control weeds. Based on their findings, a Colorado State University wheat breeder developed a two-gene hard red winter Clearfield wheat, which is much more tolerant to Beyond herbicide. A more tolerant wheat variety has allowed for more aggressive and effective control of stubborn weeds such as feral rye. Studies also examined wheat injury rates due to certain rates, timings, and combinations of herbicide applications. In two trials in eastern Oregon, all of the tested winter wheat varieties exhibited injury if Osprey was applied in cold conditions. Although Aim and Vida applications caused irregular necrotic flecks on the leaves of Goetze, Skiles, and cultivar 726 wheat varieties shortly after application, the wheat recovered, and no further injury was documented from the additional 16 herbicide treatments. Researchers also evaluated Tubbs 06 and 301 (an experimental variety near release) under western Oregon growing conditions and detected no major herbicide sensitivity problems.

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Long-term field experiments and genetic analysis were also used to identify problematic herbicide-resistant weed varieties. For example, researchers surveyed wheat fields for herbicide-resistant hybrid weeds produced by crossing of jointed goatgrass and Clearfield wheat. A Montana project assessed the synergistic effects of stressors like soil moisture, pests, and viruses on both wheat yields and weed yields. Findings will help scientists evaluate whether the joint usage of pathogens, insects, and herbicides provides efficient, durable management of weeds like Canada thistle.

In several studies, researchers treated different weed samples with a wide range of existing and newly developed herbicides to determine weed sensitivity and proper herbicide application rate. Montana State University researchers screened herbicides under a range of environmental and crop conditions. Under cold conditions, herbicide uptake by weeds was limited, allowing weeds to survive a field application. In another study, fall applications of three different herbicides provided greater than 90% control of downy brome, while spring applications provided only about 60% control.

WERA-77 also identified non-chemical methods for controlling invasive weeds in wheat. Researchers found that increasing wheat seeding rate and crop height reduced weed seed production by approximately 30% and 20%, respectively. Field and greenhouse studies showed that burning narrow windrows can reduce Italian ryegrass seed survival and can be an effective tactic for integrated control of Italian ryegrass in the Palouse region of eastern Washington and northern Idaho. Italian ryegrass emergence was 63% in the non-burned control, 48% in the burned standing stubble, and 1% with burned windrow treatments. Researchers also found that higher elevation and steeper slope reduced mayweed chamomile and common lambsquarter weed presence. Looking at how conservation tillage and crop rotation practices affect weeds, researchers found that Italian ryegrass and mayweed chamomile weeds increased when crops rotated from winter wheat to spring wheat to spring alternative crop with a no-tillage system. Other studies showed that using canola as a winter rotation crop effectively controls winter grass weeds. Researchers also showed that grazing sheep on grain stubble could impact weed communities and population dynamics. To reduce movement and dispersal of invasive weed seed sources, researchers evaluated weed seed dormancy and longevity and developed methods to help manage weed seed banks.

Extension

To encourage adoption of new weed control strategies, WERA-77 developed outreach programs to provide up-to-date information on weed management to wheat growers, crop consultants, grain merchandisers, grain processors, Extension personnel, and other scientists. Researchers at Oregon State University and Washington State University hosted tours of research trials for interested industry partners. These tours have allowed about 150 individuals representing multiple companies to see demonstrations and have open discussions. Oregon State University Extension, researchers, and faculty developed and taught a Wheat Production Short Course. The course was well-received and attended by western Oregon wheat growers, agricultural chemical industry personnel, faculty, and students. Project members also delivered presentations at several industry-grower meetings and Extension meetings and produced hard copy and online Extension bulletins. Colorado State University and Montana State University developed an electronic key to identify weed species, and in Idaho, project members created the Herbicide Resistance and Persistence computer program, which is available for free download. WERA-77 members from Idaho, Washington, and Oregon also published—and continuously updates—chapters in the Pacific Northwest Weed Management Handbook.



The Palouse region in the northwestern US is rapidly adopting canola as a winter rotation crop to control weeds in wheat fields. Photo by SeattleForge, Flickr.

Want to know more?

This project was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act to encourage and enhance multistate, multidisciplinary research on critical issues that have a national or regional priority. Additional funds were provided by contracts and grants to participating scientists. For more information, visit <http://www.waaesd.org>.

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Montana State University
Oklahoma State University

Oregon Cooperative Extension
Texas AgriLife Extension Service
Utah State University
Washington State University
University of Wyoming

Impact Statement compiled by Sara Delheimer.

Developing the US National Virtual Herbarium

WERA-1015 (2009-2014)

Herbaria Offer a Wealth of Resources, but Need to Be Modernized

In the 1540s, the creation of the first herbarium, a systematically arranged and labeled collection of preserved plant specimens, transformed plant science and taxonomy. Herbaria provided—for the first time—an effective way to document the plants of a particular region. In recent years, the more than 625 herbaria in the US have provided a rich source of information about plant diversity and distribution; however, these individual herbaria are disjointed, and many records are not digitized or available online. Easy access to herbaria is increasingly important for land management and conservation work. To make herbaria more complete, more integrated, and easier to use, herbaria need to take advantage of new digital and Web-based tools. To do so requires engaging those in charge of herbaria, building bridges between plant scientists and computer scientists, and raising awareness of herbarium resources among scientists, consultants, students, and members of the public.



Records in many herbaria now include a digital image of the specimen along with a ruler, color standards, and a barcode. Specimen images prepared by Sandy Long, Intermountain Herbarium.

Multistate Project Coordinates National Virtual Herbarium

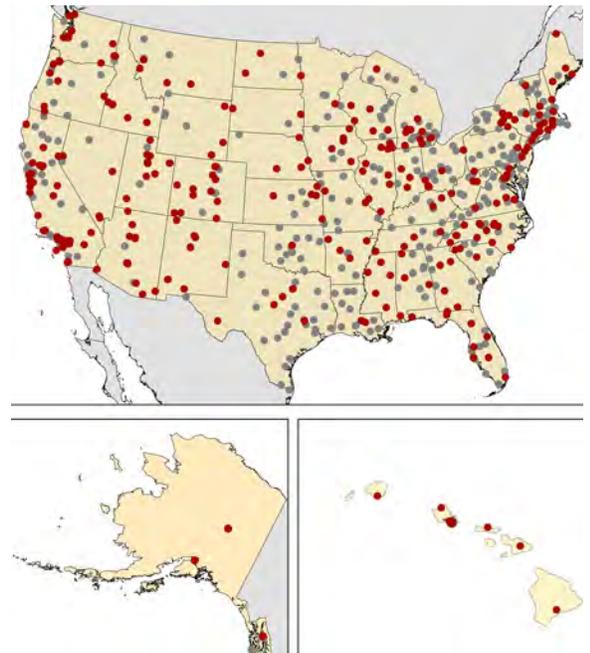
In 2009, representatives from herbaria across the country formed Multistate Research Project WERA-1015 to coordinate the development of a US Virtual Herbarium (USVH).

Early on, the WERA-1015 group conducted surveys to identify the critical functions of a national portal and determine software requirements. To build towards their goal of a single, national database, project members shared information and support with individual herbaria, including new protocols for storing specimen, recording specimen data, improving human resources, and making the work flow more efficient. The group also recommended available software and suitable hardware that herbaria could use to digitize their collections and make their resources accessible online.

The group's website (<http://usvhproject.org/>) provides information about the project, links to the existing regional networks, resources for those interested in digitization, and maps showing the status of digitization in individual herbaria. In addition to trainings and other outreach events, project members have given presentations at workshops and symposia to increase awareness and funding.

At the start of the project, there were only three regional or national herbarium networks. Today, networks cover the whole country and continue to expand to include more herbaria. By the end of 2015, 235 herbaria were sharing records through a regional network. Integration enables individuals to access from multiple herbaria in the region. In August 2015, survey responses indicated there were about 17 million records accessible through one of the major networks, a huge increase of over the number reported for 2011.

In 2014, a joint committee was established between USVH and iDigBio—the National Science Foundation-funded national portal for all organisms. With NSF support, WERA-1015 is helping the iDigBio project find ways to overcome the challenges of establishing a national portal, in particular, integrating herbaria that use different database platforms.



Several robust regional networks now exist for vascular plants, the group best represented in herbaria, and national networks exist for less represented groups, including bryophytes, lichens, fungi, and algae. Each red dot on this map shows an herbarium that is contributing to one or more networks. Gray dots show herbaria not connected to a network. Multistate coordination and resource sharing eliminates redundant efforts and reduces the overall cost and difficulty of constructing these networks, and potentially, the USVH. Map generated by Mary Barkworth, Utah State University.

Multistate Project Improves Quality and Accessibility of Herbaria Resources

WERA-1015 has increased knowledge of the resources herbaria provide and made these resources more readily accessible. By providing free access to verifiable, downloadable information on plants and their distribution, advances in accessibility facilitate research projects and save researchers the time and cost of traveling to specific plant sites or specimen libraries.

WERA-1015's work has encouraged specimen collectors and herbaria personnel to adhere to international standards and use new tools to record more, better quality information. Higher quality records make it easier to integrate specimens into herbarium databases and networks. New tools and standards also increase the value of new collecting activity.

Having distributional information and digitized images stored online facilitates accurate identification of specimens collected in the field. Furthermore, access to modernized herbaria resources is helping develop plant identification and taxonomic skills needed to work at agencies like the US Forest Service.

Increased knowledge of plant distributions in the US over time enables more accurate ecological modeling, better land management, sustainable agricultural planning, and improved assessments of climate change impacts. In particular, this data can be used to predict areas to which an introduced species or insect pest will spread or where additional populations a native species be found.

Want to know more?

WERA-1015 was supported, in part, through USDA's National Institute of Food and Agriculture by the Multistate Research Fund established in 1998 by the Agricultural Research, Extension, and Education Reform Act to encourage and enhance multistate, multidisciplinary research on critical issues. Additional funds were provided by contracts and grants to participating scientists. For more information, visit <http://www.waaesd.org>.

Herbarium Networks

- Pacific Northwest: pnwherbaria.org
- Pacific Herbaria: pacificherbaria.org
- Northeastern: neherbaria.org
- California: ucjeps.berkeley.edu/consortium
- Intermountain: intermountainbiota.org*
- Midwest: midwestherbaria.org/portal*
- New Mexico: nmbiodiversity.org*
- Northern Great Plains: ngpherbaria.org/portal*
- Small herbaria: nansh.org*
- Southeast: sernecportal.org*
- Southwest: swbiodiversity.org*

*These networks are connected by SEINet, a super-regional network: swbiodiversity.org/seinet

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University of Alabama	University of Nevada, Las Vegas
Appalachian State University	University of North Carolina, Wilmington
Arizona State University	North Carolina Cooperative Extension
Arkansas Tech University	University of Oklahoma
Auburn University	Oregon State University
Black Hills State University	Portland State University
Boise State University	Rutgers University
University of California, Davis	University of Tennessee, Chattanooga
University of the Cumberlands	Troy University
Delaware State University	Truman State University
Fairmont State University	Utah State University
George Mason University	Utah Valley University
University of Georgia	Valdosta State University
University of Hawaii	Vanderbilt University
Iowa State University	University of Vermont
James Madison University	Virginia Polytechnic Institute and State University
Kansas State University	University of Washington
University of Louisiana, Monroe	West Virginia University
Louisiana State University	Western Carolina University
Lynchburg College	University of Wisconsin
University of Michigan	
Michigan State University	
University of Mississippi	
Mississippi State University	
Northern Arizona University	
University of New Hampshire	

Participating Institutions:

Academy of Natural Sciences of Philadelphia
Botanical Research Institute of Texas
Center for Biological Informatics
Firesner Herbarium
Idaho Museum of Natural History
Herbarium
The Morton Arboretum
Smithsonian Institution
USGS



The top image shows a 3D modeling experiment of a Lace Lichen. Photo by Timothy M. Jones. Bottom specimen image prepared by Sandy Long, Intermountain Herbarium.