NIFA SUPPORTED ACTIVITIES RELATED TO CLIMATE AND ONE HEALTH

TAWNEY FREEMAN AND ISABEL WALLS

United States Department of Agriculture
National Institute of Food and Agriculture

Table of Contents

Water Quality

Identification and Enumeration of E. coli and the Impact of Climate Change and Variability to Determine the Water Quality in the Flint Creek Watershed (FCW) …………………………………………………..…. 3

Algal Biology, Ecology, Management, and Utilization ……………………………………………………………..…….. 4

Assessing Threshold Benefits of Conservation Tillage During Drought Years: Implications for Nutrient Use Efficiency and Water Quality …………………...……………………………………………………………………. 5

Water Resource Risk Analysis and Management in Agricultural Systems ………………………………………………. 6

Assessment of Global Climate Change Impacts on Water Resources and Crop Productivity and Adaptations by Limited Resource Farmers and Landowners in the Black Belt Region of Alabama ………..….…. 7

Crop, Climate, and Land Use Interactions ……………………………………………………………………………….. 8

Tracking Petroleum Hydrocarbons in Stormwater …………………………………………………………………….…. 9

Food Safety

Contaminants of Emerging Concern (CECs): From Treated Wastewater to Biosolids to Fresh Produce ………………………………………………………………………………………………………...….…. 10

Bioaccumulation and Departure of Nanoparticles by Marine Bivalves: Potential Foodborne Hazards and Implications for Shellfish Safety ……..……………………………………………………….…………. 11

Ecosystem Factors Affecting *Vibrio parahaemolyticus* Populations and Potential Impacts on Shellfish Safety ……………………………………………………………………………………………………..…. 12

Agrochemical Impacts on Human and Environmental Health: Mechanisms and Mitigation …………………………… 13

Marketing and Delivery of Quality Grains and BioProcess Coproducts ………………………………………………….. 14

Endemicity of Pathogenic *Vibrio parahaemolyticus* in New England Shellfish Waters …………………………………. 15

Genetic, Phenotypic, and Genomic Plasticity in Experimentally Evolved and Natural Populations of Aspergillus ……………………………………………………………………………………………….. 16

Vector-borne Diseases

California in an Era of Global Change: Biodiversity Loss and Threats from Emerging Infectious Disease ………...….. 17

Biology, Ecology, & Management of Emerging Disease Vectors (Rutgers University) …………………………………. 18

Biology, Ecology, & Management of Emerging Disease Vectors (University of Kentucky) …………………………….. 19

Biology, Ecology, & Management of Emerging Disease Vectors (Michigan State University) ………………………… 20

Immunological and Abiotic Effects on Ectoparasite Population Dynamics ……………………………………………. 21

Overview

Climate-related events, such as increased heat, drought, and flooding are impacting human health, animal health and the environment in unprecedented and often negative ways. These include issues associated with water quality, foodborne pathogens, and vector-borne infectious diseases. The USDA is actively working to understand and mitigate these issues through a variety of research projects. Currently, there are seven regarding water quality, seven associated with food safety, and five with regard to vector-borne diseases. These reports include current and recently terminated projects, which were found within CRIS, REEIS, FSRIO, and ARS websites (www.cris.nifa.usda.gov; www.reeis.usda.gov; www.ars.usda.gov; www.ars.usda.gov).

Identification and Enumeration of *E. coli* and the Impact of Climate Change and Variability to Determine the Water Quality in the Flint Creek Watershed (FCW)

Director: Elica Moss
Start Date: 2014
Alabama A&M University
NIFA Formula
1002291

Key points: climate change/variability; water quality and E. coli presence in runoff

Abstract: Improved watershed management and protection is extremely important. The aquatic environment receives significant disposal of effluents, signaling high risks of fecal microbial contamination and the general degradation of water quality. The proposed research will characterize the water quality of the Flint Creek Watershed (FCW) in northern Alabama in order to establish baseline data of potential E. coli contaminants to ultimately assist landowners in managing the risk to human and environmental health. Streams in the FCW will be selected based on drainage and proximity to animal feeding operations, which are potential sources of pathogen contamination. Fecal coliforms are used worldwide as microbiological water quality indicators due to their abundance and their behavior as pathogens, which could represent a higher health risk. Additionally, watershed are sensitive to perturbations in climatic events such as temperature and rainfall, which could have significant effects on the concentrations and sources of fecal bacteria. Thus, this research will (1) Establish a map of the FCW through the identification and enumeration of the number of E. coli fecal indicator bacteria and identification of the physiochemical parameters that may serve as drivers to the presence and density of E. coli, (2) Evaluate the impacts of climate change/variability, land use change, and demographic change on the presence of fecal bacteria indicators in the FCW, and (3) Enrich water quality education through student training and extension. Therefore, it is imperative that the FCW is thoroughly studied through the establishment of baseline data to characterize water quality by determining the presence of fecal indicator bacteria and determining if there is a relationship to climatic factors.

Algal Biology, Ecology, Management, and Utilization

Director: E Phlips
Start Date: 2013
University of Florida
NIFA Formula
1000035

Key points: integrity and sustainability of aquatic ecosystems; adaptation/mitigation strategies for prevention or treatment

Abstract: A substantial body of evidence now exists for the role that global human population growth and development have played in the acceleration of eutrophication, increase in pollution, and climate change. Over the past century, widespread land use change and acceleration in the rate of cultural eutrophication have led to increases in harmful algal blooms in aquatic ecosystems around the world. As a state with over 7,500 lakes and the second longest coastline in the United States, the wellbeing of Florida is dependent on the integrity and sustainability of its aquatic environment. Scientists and water managers around the world are faced with the difficult challenge of providing effective strategies for preventing harm to aquatic ecosystems that are still healthy and improving the quality of environments that have been significantly degraded. The integrity of aquatic ecosystems is essential to sustaining the functions and resources critical to the wellbeing of fisheries, water supply, recreational opportunities, and more fundamentally, the stability of the biosphere. This project focuses on this challenge as it relates to primary producers (i.e. bacteria, algae, and higher aquatic plants), which form the base of aquatic food webs and provide critical structure in marine and freshwater habitats. Aquatic primary producers can also form the basis for the development of new, environmentally-friendly technologies aimed at filling the growing global demand for food, energy, and chemicals, as illustrated by recent efforts to convert algae into biodiesel and the discovery of algae that produce anti-cancer drugs. Whereas many of the research efforts in the project will be located in Florida, the results of the work have application to environments around the world, particularly in warm-temperate, subtropical and tropical environments. The overarching theme of the project is the role of algae and other aquatic primary producers (i.e. bacteria and aquatic plants) in the structure and function of ecosystems, both natural and anthropogenic. The primary objectives are to (1) Determine the factors that control the structure and function of primary producer communities in marine and freshwater ecosystems, (2) Define the adverse consequences of changes in the environment for the integrity and sustainability of aquatic ecosystems, such as harmful algal blooms or anoxia, (3) Develop new strategies for preventing or mitigating damage to ecosystems related to changes in aquatic primary producer communities, (4) Produce models that can help predict the responses of ecosystems to changes in environmental conditions, including those resulting from the implementation of management strategies, (5) Explore new technologies for the use of primary producers in the production of food, feed, fuel, and chemicals, and (6) Apply new genetic methodologies and approaches to address research challenges and opportunities.

Assessing Threshold Benefits of Conservation Tillage During Drought Years: Implications for Nutrient Use Efficiency and Water Quality

Director: Pierre-Andre Jacinthe
Start Date: 2014
Indiana University (Trustees)
NIFA Non-Formula
1004899

Key points: drought; mitigation strategies for nutrient run off of nitrates; water quality

Abstract: Intensive agriculture in the United States Midwest has been linked to various water quality problems in the Mississippi River basin and the expansion of the so-called "dead zone" in the Gulf of Mexico. The problem could become more serious if summer droughts, such as in 2007 and 2012, were to become more frequent. During droughts, the utilization of applied nutrients by growing crops is notoriously low. As a result, fairly large amounts of nutrients remain in the ground at harvest, and these nutrients are typically transferred to streams and rivers (runoff and tile discharge) causing degradation of water quality. Following the 2012 summer drought, for example, unusually high nitrate concentrations (2-4 times higher than the maximum limit allowed by the EPA for drinking water) were recorded in streams draining agricultural watersheds in Iowa, Illinois, and Indiana. Many of these streams are sources of drinking water for several municipalities in the region. The management of water quality in the US Midwest streams is intrinsically connected to agricultural land management, especially in a variable climate. With adoption of appropriate management practices, water quality protection can be achieved without sacrificing agricultural profitability. Agricultural producers may not necessarily be aware of the water quality impact of their farming operations, but an effective way to raise that awareness is to demonstrate the financial benefits of alternative management strategies. In this integrated project, we therefore argue that soil quality, achievable with conservation tillage, is the cornerstone of water quality. Compared to conventional tillage, studies have shown that no-till practice results in better crop yield and less residual soil nutrient after summer droughts. We propose to investigate the effect of tillage management on nutrient cycling, water budget, and crop productivity during drought years, and to identify the socio-economic barriers to the adoption of conservation practices in agro-ecosystems. Our project will be conducted inthe Eagle Creek watershed in Indiana. Satellite images collected (and archived) during the last 10-15 years will be analyzed to determine the distribution of tillage practices throughout the watershed. Landsat images will be used to estimate drought severity every 16 days throughout selected growing seasons (2007 and 2012 as drought years, 2010 as a normal year). We will then identify fields under conventional and no-till practices, and determine how tillage practices determine the response of crops to summer droughts of varying intensity.

Water Resource Risk Analysis and Management in Agricultural Systems

Director: RA McDaniel
Start Date: 2016
South Dakota State University
NIFA Formula
1009076

Key points: water quality; pathogens related to agricultural practices; impacts from drought and flooding

Abstract: Agricultural production is heavily dependent on water resources. Water resource quality and quantity are also greatly affected by agricultural practices at all scales. An excess or lack of water can detrimentally affect both economic productivity and yield productivity. Producers have turned to agricultural tile drainage to reduce excessive soil moisture, which has caused changes in the hydrology of these areas. This practice has led to both increased and decreased water resource risks. On the other hand, water availability in areas of inadequate precipitation is essential and a lack of water availability increases risks associated with agriculture as well as water resources. Physical factors within the environment can impact the risk of management practices on water resources. Erosion and subsequent sediment loads to waterbodies, for instance, are influenced by shear stress from water flow, soil type, etc. Evaluating the impact of these physical factors on water risk will improve the ability to assess local risks and scale-up appropriately to assess watershed risks. The proposed project will incorporate analyses of physical factors contributing to water resource risks, management practices to reduce water resource risks, and evaluation of risks to and from agricultural systems as a whole. A major focus area of risk analysis will be assessing the impact of physical factors from agricultural systems on risks to water bodies, such as streams, rivers, and lakes. Nearly 60% of South Dakota's assessed rivers and streams are impaired and another 10% are threatened with impairment. The primary causes for impairments are pathogen indicators, including E. coli and fecal coliform, and total suspended solids (TSS). Livestock, wildlife, and crop production were determined to be the most probable sources of impairment in South Dakota. Some physical factors, such as soil type and organic matter, can effect E. coli survivability in environmental systems while others, such as attachment rates and shear stress, can affect the transport of E. coli. Both survivability and transport contribute to high concentrations in water systems, which can pose a risk to human health. From existing data and the aforementioned assessments, evaluations of management practices and systems risk will be performed. Agricultural management practices used to improve water quality include controlled drainage, saturated buffers, and seasonal riparian buffers. These management practices will be assessed for their ability to reduce pollutant transport and thus risk to water bodies. As precipitation patterns change, managing water resources becomes more important. Water resource management will be examined to understand and mitigate risk associated with excessive and insufficient moisture conditions that may result from these changing precipitation patterns as well as natural climate variability.

Assessment of Global Climate Change Impacts on Water Resources and Crop Productivity and Adaptations by Limited Resource Farmers and Landowners in the Black Belt Region of Alabama

Director: Joseph Essamuah-Quansah
Start Date: 2014
Tuskegee University
NIFA Formula
1001194

Key points: water quality; adaptation

Abstract: Global climate change alters hydrologic cycles and regimes within watersheds, adversely impacting water quality and quantity, sustainable agriculture and the environment. Understanding and predicting the interactions between water systems and climate change are consistent with CBG USDA Priorities and NIFA Challenge areas. The proposed project will (1) predict climate change at local scale, assess likely impacts on water resources and agricultural production at subwatershed scale, (2) quantify impacts of historical and future climate changes on water quality and quantity and community vulnerability, and (3) identify adaptations options to climate change for end users in the Black Belt counties. The historical and simulated climate data and other geospatial data will be assimilated into the Soil and Water Assessment Tool and the CROPGRO model to establish baseline conditions and forecast the impacts of climate change on water quality and quantity and agricultural production. The project will build and strengthen the capacity of Tuskegee University (TU) to develop and provide climate change adaptation strategies and watershed management solutions for sustainable agriculture and water resource management. The project will be pivotal for continued integrative research activities by faculty and the engagement of graduate students in research and educational and outreach programs. Findings will be incorporated in curricula and published in peer-reviewed journals, bulletins, and are expected to enhance climate change awareness amongst socially and Historically Disadvantaged Farmers and Cooperatives.

Crop, Climate, and Land Use Interactions

Director: Nathan Moore
Start Date: 1007604
Michigan State University
NIFA Formula
1007604

Key points: food production and food security; changes in land and water use/availability

Abstract: My research project is primarily aimed at better understanding long-term trends in climate-affecting agriculture. Food production can be altered by long-term shifts in climate; this has been observed as far back as the Natufians and the dawn of agriculture in the fertile crescent all the way to the present, where changing irrigation patterns are affecting crop choice in the Texas High Plains. I am particularly focused on three areas: The Great Lakes, The High Plains Aquifer, and East Africa. Harmful algal blooms (HABs) in the Great Lakes are closely linked to decisions of land use, fertilizer application, and climate. Is there a specific combination of weather, crops, and fertilizer inputs that could increase the risk of HABs in Lake Erie? The project seeks to build a mechanism to better estimate and predict such events and risk. For the High Plains, irrigation has greatly altered the landscape from brown and dry soils to dark green and moist soils. This change has altered the regional climate and the ability of the region to produce food, but its sustainability is limited and difficult to accurately predict. I am working to understand how that system might collapse due to changes in land use and water extraction. Food security in East Africa has been highly variable over the last century despite massive efforts including the Green Revolution. The region is prone to food insecurity and yet the causes are poorly characterized in general due to so many interlocking factors. This semi-arid tropical region is practically defined by change: shifting economic structures, political instability, agricultural shifts, and climate change. To successfully improve food security the region needs better predictions and more robust models of how the integrated human-environment interactions function. All of these problems can be tackled with better integration of process-based models. I am working on developing such fully coupled models with extensions into agriculture, land use, and even (eventually) economic decisions. The climate projections we ruse rarely explain how reliable estimates are, how skillful the models are, and how and where the models have performed inaccurately or imprecisely based on historical data. As a result, often research groups download data to put into their model in a one-way fashion, like downloading climate data for use in a hydrologic model, and yet the very system they are studying has feedbacks back to the climate data. My project aims at understanding those limitations and constructing better tools for studying these systems.

Tracking Petroleum Hydrocarbons in Stormwater

Director: J Martin
Start Date: 2012
Ohio State University
NIFA Formula
187013

Key points: stormwater; carcinogens; and harmful hydrocarbons

Abstract: Carcinogenic and mutagenic hydrocarbons in stormwater and receiving streams highlight the need to find effective methods to remove these pollutants from stormwater before they accumulate in downstream water bodies. Recent results indicate that bioretention systems, or rain gardens, may represent an effective, low-cost ecological solution. Bioretention systems (1) are less expensive than conventional centralized sewer and treatment systems, (2) restore ecological function to developed areas by retaining stormwater on the landscape, and (3) have proven effective at reducing storm runoff, nutrients, and some heavy metals. Because of these attributes, bioretention systems have been identified as best management practices and are being increasingly applied in stormwater management plans. However, there are important questions that remain related to their ability to reduce hydrocarbon pollutants. An initial study has demonstrated the ability of a single bioretention system to significantly reduce by ~87% a subset of petroleum hydrocarbons found (16 polycyclic aromatic hydrocarbon [PAH] compounds) in stormwater. In actuality, there are numerous other deleterious petroleum derived-hydrocarbons found in urban stormwater in addition to PAHs. This research will address this major gap in our understanding of remediating stormwater with ecological methods and answer the question of how effectively bioretention systems can reduce total petroleum hydrocarbons in urban stormwater. This proposed work is the first to apply natural carbon type analyses to quantify the reduction of the total range of petroleum hydrocarbons produced by a stormwater treatment technology. To complement the proposed isotope approach, conventional methods will also be used (analyses of PAH and total petroleum hydrocarbons [TPH]) to compute mass balances entering and exiting existing street-side bioretention systems in central Ohio. New knowledge gained from this research will improve the design of bioretention systems to maximize water quality improvements and offer other important insights into how best to monitor petroleum hydrocarbons to protect the health of humans and ecosystems.

Food Safety

Contaminants of Emerging Concern (CECs): From Treated Wastewater and Biosolids to Fresh Produce

Director: Jianying Gan
Start Date: 2016
University of California, Riverside
NIFA Non-Formula
1007559

Key points: water quality; contaminants; education and training; produce

Abstract: The use of reclaimed water and biosolids in agriculture has increased drastically due to worsening water scarcity and rising need for waste disposal. Reuse of such previously underutilized resources has important economic and environmental benefits, but also poses unknown risks to consumers due to the potential introduction of many contaminants of emerging concern (CECs) into food products. The perceived risks are the greatest for fresh produce, such as vegetables and fruits that are often consumed raw. However, the occurrence and levels of CECs in vegetables and fruits under field conditions are essentially unknown, preventing assessment of the associated food safety. This project aims to improve food safety by evaluating emerging and under-researched chemical hazards in fresh produce. Specifically, we will first conduct greenhouse and cell-based experiments to develop a short list of CECs that have a high tendency for plant accumulation, and then measure the actual levels of these priority CECs in edible parts of common vegetables (lettuce, spinach, cabbage, celery, tomato, pepper, cucumber, radish, carrot, onions) and fruits (strawberries, melons, apples, citrus, avocado, plum) grown with treated wastewater irrigation or biosolid amendment in fields in Southern California. We will further use typical consumption values to estimate dietary intakes of CECs for different age groups and predict potential human exposure risks. Working with county-based farm advisors in California, we will actively extend science-based information to growers and the general public to promote safe reuse. This project contributes to a sustainable U.S. agriculture by promoting the use of treated wastewater and biosolids as valuable resources while safeguarding consumers.

Bioaccumulation and Depuration of Nanoparticles by Marine Bivalves: Potential Foodborne Hazards and Implications for Shellfish Safety

Director: J.E. Ward
Start Date: 2015
University of Connecticut
NIFA Non-Formula
1007724

Key Points: water quality; chemical contaminants; manufactured nanoparticles; outflow from wastewater treatment facilities; flooding; DNA damage; oxidative stress; and inflammation

Abstract: Manufactured nanomaterials are being used in a variety of consumer products including sunscreens, cosmetics, personal-care products, and paints. Nanomaterials are extremely small compounds having at least one dimension less than 100 nanometers. With an increasing presence in household goods, the demand for and the production of nanomaterials composed of carbon, metal oxides, polystyrene and silica has also increased. As the production of nanomaterials increases, so too does the likelihood of release into the environment as a result of spills, use of products, post-consumer degradation of materials, leaching from septic tanks and landfills, or outflow from wastewater treatment facilities. Many questions regarding the environmental safety of nanomaterials have been raised. Toxicological effects of nanoparticles in humans are well studied and include inflammation, oxidative stress, and DNA damage. Comparatively little research has focused on the effects of nanomaterials on marine ecosystems, or whether this class of emerging pollutants could be transferred through marine food webs to humans. Coastal ecosystems near densely populated, industrialized regions are particularly vulnerable to the infiltration of man-made materials, such as nanoparticles. Filter-feeding bivalves, such as clams, mussels, and oysters, which are harvested or cultured for human consumption, are particularly susceptible to nanoparticle exposure given their abundance in coastal waters and their particle feeding behavior. Few studies, however, have addressed how these animals encounter nanoparticles in the environment and little is known about the accumulation and elimination of nanoparticles by bivalves. In this project, we will investigate whether nanoparticles could be a foodborne hazard in shellfish. Specifically, we will study: (1) The way in which bivalves encounter and inject nanoparticles, (2) Whether they accumulate nanoparticles during chronic exposure, and (3) If bivalves can eliminate the nanoparticles from their body after exposure ceases, and if so, how long does it take. Results will provide realistic estimates of exposure and bioaccumulation of nanoparticles in shellfish, and help elucidate the potential for nanoparticles to be passed to higher trophic levels including humans. Ultimately, new knowledge generated by our research will inform decision makers and guide strategies for the management of this class of emerging pollutants, and help to ensure and improve shellfish safety.

Ecosystem Factors Affecting *Vibrio parahaemolyticus* Populations and Potential Impacts on Shellfish Safety

Director: S Jones
Start Date: 2017
University of New Hampshire
NIFA Formula
1010499

Key points: Vibrio; shellfish; pathology

Abstract: Oyster aquaculture in northern New England has realized substantial increases in the number of producers and overall production in the past 10 years, yet the associated economic benefits are threatened by the northward emergence and increased incidence of V. parahaemolyticus-borne illnesses in consumers of oysters from New England states. The most affected states have initiated monitoring programs to track this and other Vibrio species, and are instituting increasingly more stringent management practices on farmers to reduce public health risks. There are significant limitations to the existing state of knowledge for much of this, including the, until recently, lack of tools to track the rare strains of *V. parahaemolyticus* that actually cause illnesses. Continued development of improved Vibrio detection methods and models based on environmental and biological conditions for predicting risks of Vibrio-borne illnesses will address growing regional concerns and reduces costs for all involved. Use of newly-developed pathogen detection methods will aid our understanding of microbial dynamics in estuarine ecosystems to address long-outstanding scientific questions about how and why these pathogens emerge and proliferate, and for reducing concerns by shellfish consumers about the safety of what they eat. The project will address regional concerns about expanding *Vibrio parahaemolyticus* populations and potential impacts on shellfish safety using development of improved Vibrio detection methods and models based on environmental and biological conditions for predicting risks of Vibrio-borne illnesses. The specific objectives are (1) Determine seasonal environmental factors that correlate with total and pathogenic *V. parahaemolyticus* populations and the emergence of pathogenic strains in oysters and overlying waters in New England, (2) Evaluate key planktonic and estuarine microbiome factors that affect *V. parahaemolyticus* population levels and diversity in oysters, and (3) Develop predictive models of risks associated with *V. parahaemolyticus* and provide outreach to help shellfish programs and growers reduce human illnesses through harvest management.

Agrochemical Impacts on Human and Environmental Health: Mechanisms and Mitigation

Director: CH Ray
Start Date: 2016
University of Nebraska
NIFA Formula
1011588

Key points: food safety; bioaccumulation of selenium, arsenic, and uranium in crops/water/soil

Abstract: The four-year project will look closely at the transfer of arsenic, uranium, and selenium from soil or irrigation water to food and feed crops, which to date have not been well studied. This will improve our understanding of the fate of these chemicals in the environment as well as their impacts to humans and animals. The study helps us in devising remediation mechanisms or seeking alternative approaches to increased food production. A prime objective of the research is gaining a better understanding of how plants uptake uranium, selenium, and arsenic in different stages of their development and in harvested agricultural crops that were irrigated with surface and groundwater high in these chemicals. We will also examine the mobilization of these chemicals in leachate leaving the root zone. Field sites in western and central Nebraska will be monitored over a period of three years. Field experiments will also be conducted at UNL's Panhandle Research and Extension Center (PREC) near Scottsbluff, where surface water is used to grow a variety of crops. Local natural resources districts (NRDs) will be consulted to help locate key producers using surface water irrigation, who will let us sample water, soil, and plant material and install sampling equipment. The study will show which elements are more likely to be taken up by major food/feed crops and will also show which crops are prone to accumulate higher amounts of chemicals under no or moderate soil moisture stress conditions. Where surface water is used for irrigation, we will learn if there is substantial amounts of these chemicals present in leachate, which has the potential to reach groundwater. Public health is one of the major concerns of plant uptake of these chemicals. If some of the crops hyper-accumulate these chemicals, it can become a marketing issue and health concern for these products.

Marketing and Delivery of Quality Grains and BioProcess Coproducts

Director: Dojin Rye
Start Date: 2014
University of Idaho
NIFA Formula
1001948

Key points: mycotoxins; development during drying and storage

Abstract: Mycotoxins are toxic compounds produced by certain filamentous microfungi or molds. Mycotoxins considered to be important, including aflatoxins, ochratoxins, fumonisins, deoxynivalenol, and zearalenone, are produced mainly by three fungal genera, Aspergillus, Penicillium, and Fusarium. Some of these fungi may invade plants and cereal grains in the field during the growing season, as well as during postharvest handling processes, such as drying and storage. Cereal grains are the most frequently affected commodity, while all major crops and commodities may be contaminated with one or more mycotoxins. Moreover, the stable nature of mycotoxins often leads to contamination of products in downstream processes including finished products destined for human and animal consumption. Infection of mold and subsequent toxin production may occur naturally in any condition. However, among the various environmental factors, temperature and precipitation are considered the most critical for invasion, growth, and toxin production in the grain field. For instance, cool and wet weather during the growing season seems to be the most important factor for wheat in the development of Fusarium head blight (FHB), as well as accumulation of trichothecenes (including deoxynivalenol). Recent variability in climate prompted better understanding of agroecosystems to ensure grain quality and food safety since the fungal infection and mycotoxin production may not remain the same under the varying environmental conditions. It is particularly true in the Pacific Northwest, where the natural precipitation in the past allowed agricultural commodities, e.g. wheat to be cultivated without irrigation. The lack of extreme fluctuation in temperatures during the growing season also contributed to the higher yield of crops in comparison to those from other regions. However, increasing daily and seasonal fluctuation of temperature in addition to the variability in precipitation due to climate change would affect mycotoxin production. Variability in climate may cause changes in soil systems, including organic and inorganic matter, where plants are rooted to grow. As many plant pathogenic fungi and mycotoxin producers, e.g. Fusarium species, are soilborne and their population is largely affected by the climate and soil system, it would be plausible to investigate the impact of climate changes on the soil system that will determine toxigenic fungal population and their potential in growth and survival of the organism as well as mycotoxin production. Therefore, Pacific Northwest region may provide a unique model system to study impact of climate variability on agroecosystem particularly in fungal population in the soil and quality of grains by assessing potential for mycotoxin production in wheat and other agricultural commodities.

Endemicity of Pathogenic *Vibrio parahaemolyticus* in New England Shellfish Waters

Director: C Whistler
Start Date: 2015
University of New Hampshire
NIFA Formula
1004199

Key points: detection of *Vibrio parahaemolyticus* in shellfish; gastroenteritis

Abstract: The bacterium Vibrio parahaemolyticus is a common member of the marine environment and it can periodically cause devastating outbreaks of gastroenteritis. Projections suggest as many as 45,000 foodborne infections a year are caused by *V. parahaemolyticus*, and it is the most common seafood-borne bacterial infection in the United States. Even as public health officials and shellfish managers grapple with developing appropriate protective strategies, it is becoming increasingly apparent that we are unable to explain the exact cause of increased incidence here in New England that is necessary to inform management and regulatory strategies. The current change in disease incidence in this cooler climate presents a timely opportunity to identify the environmental factors that drive changes in the occurrence of pathogen-related strain types informing the development of measures to reduce human disease. The shellfish aquaculture industry has suffered increasingly more frequent vibrio-associated disease outbreaks linked to shellfish consumption, both on a national, and very recently on a regional scale. These outbreaks and even individual cases of disease have had a widespread and cumulatively devastating impact on markets. Concerns about shellfish safety for the public has prompted discussion about implementation of further restrictions on the marketing of live fresh shellfish from certain at risk regions that could be economically crippling to the shellfish industry. Because of this, the top priority of the east coast shellfish growers industry is to reduce food-borne illnesses associated with their products. We will identify pathogenic strains in the region, fully sequence their genomes, and through comparisons identify unique traits that identify a strain as a known pathogen. This pathogen profiling strategy, will then be used to develop detection tools. The specific detection tools will then be used in simple laboratory experiments to evaluate to what extent the pathogens can be quantified among a mixed population, and we will then examine a series of conditions for their ability to cause an increase in the pathogenic strains. Once the method is developed and piloted, we will be positioned to evaluate environmental conditions that influence pathogen abundance in shellfish harvest areas. Additionally, we will provide the molecular detection tools to shellfish managers to improve their ability to monitor shellfish beds and make science-based decisions about harvesting, such as shellfish bed closures, and reopening after a closure. Ultimately these efforts will protect the shellfish industry from the effects of bad press when product is found unsafe by better ensuring a safe product, and promote public safety through the prevention of disease.

Genetic, Phenotypic, and Genomic Plasticity in Experimentally Evolved and Natural Populations of Aspergillus

Director: Ignazio Carbone
Start Date: 2014
North Carolina State University
NIFA Formula
1002244

Key points: microbial toxins; foodborne disease; mycotoxins and their predicted response to changes in climate

Abstract: Microbial populations continually adjust in response to changing environmental and ecological pressures. The importance of clonal and sexual reproduction in adaptation and diversification in Aspergillus is unknown. The integration of experimental and natural population sampling will provide the resolution necessary to understand the maintenance of important functional traits such as non-aflatoxigencity and sterility in populations. Female sterility occurs naturally and at a high frequency in populations of these fungi worldwide, but even rare sex can influence aflatoxigenicity. The proposed project will benefit from our existing culture collection of over 5,000 *Aspergillus spp*. isolates that were collected across five continents. We will use high throughput genotyping methods to provide dense marker coverage across all *A. flavus* chromosomes and populations. Soil composition and cropping practices are reported to influence A. flavus population shifts. Spectroscopic and microscopic techniques will be used to examine soil composition and chemistry. Molecular sequence variation, phenotypic and environmental data will be analyzed to establish correlations between abiotic and biotic components of soil and crop ecosystems, as a basis for modeling and making predictions on how changing specific components of ecosystems can influence aflatoxigenic fungi. Our sampling over consecutive years will allow us to estimate genotype turnover rates and model population shifts. Our inferences of significant genotype-by-environment or genotype-by-genotype interactions that may be important in population shifts will be the basis for further experiments in the laboratory that are essential for model validation and refinement. Knowledge of the abiotic and biotic components of agricultural ecosystems will be beneficial in improving biocontrol strategies. These strategies currently utilize nontoxigenic *A. flavus* strains but it is possible that other species may be more suitable. Biocontrol artificially shifts mating-type distributions in populations in favor of MAT1-2; both approved biocontrol strains are MAT1-2. Previous studies of mating-type distributions reveal that *A. flavus* populations that favor asexual reproduction have a higher percentage of nontoxigenic strains. While mating-type distributions are a useful indicator of the potential for toxin production, our ability to predict future population shifts is limited, as changes in agronomic practices, insect damage and environmental parameters such as temperature and precipitation will directly impact fungal populations. However, the results of this project will identify the biotic and abiotic components of agricultural ecosystems that are responsible for population shifts.

Vector-borne Diseases

California in an Era of Global Change: Biodiversity Loss and Threats from Emerging Infectious Disease

Director: E Rosenblum
Start Date: 2013
University of California, Berkeley
NIFA Formula
230135

Key points: fungal pathogenesis and crops; pest control; potential increase of VBDs

Abstract: My work focuses on understanding the threats to biodiversity in California, an endeavor directly linked to the long-term success of agricultural activities in our state. The objectives are to (1) Understand the threats of emerging infectious diseases in economically, ecologically, and agriculturally important species in California. Specifically, to use comparative studies of emerging fungal pathogens to understand mechanisms of fungal pathogenesis. An emerging threat to agricultural systems is novel fungal diseases. The incidence and severity of fungal infections is on the rise, and fungal pathogenesis will be important for mitigating the effects of disease. My research will provide insight into fungal pathogens that are devastating wildlife species (like bats and frogs) that provide billions of dollars in ecosystem services (in the form of pest control) to the agricultural sector. My research will also provide information on fungal pathogenesis that is critical for protecting crops.

Biology, Ecology, & Management of Emerging Disease Vectors

Director: Dina Fonseca
Start Date: 2015
Rutgers University
NIFA Formula
1004746

Key points: ticks; VBDs; adaptation and detection strategies

Abstract: Although tick-borne diseases are on the rise and Lyme disease, a tick-borne disease, is the most common vector-borne disease in the US (over 22,000 confirmed cases per year since 2007), tick control is still in its infancy. Of primary importance is to identify genetically-based differences in vectorial capacity across populations of the vector (Ixodes scapularis). Prior research using phylogenetic markers has found scant but possible evidence of a unique genetic signature in urban and suburban populations associated with Lyme (*Borrelia burgdorferi*) transmission. We propose to use next-generation sequencing tools and screen thousands of single nucleotide polymorphisms (SNPs) or several fast-evolving loci (such as Simple Sequence Repeats, SSR, or microsatellites) to reconstruct genetic signatures critical for differential vectorial capacity that are too recently differentiated to be revealed by morphological differences or most standard phylogenetic tools. In contrast, although mosquito control has a long history, it has often been reactive, which means that intensive mosquito control only occurs following a disease outbreak and is often performed under an "emergency mentality." As a result, mosquito control has relied on massive application of insecticides or habitat destruction without careful attention to either the population dynamics of the target species or the potential development of insecticide resistance. Interestingly, one of the "success stories" has been the development of strategies for control of Aedes sollicitans, the salt marsh mosquito, a tremendous biting nuisance that delayed the settling of coastal NJ. Although this species can vector deadly Eastern Equine encephalitis virus, its control was not spurred by panic but by the desire to live mosquito-free. Careful study of the life-history of the species led to the realization that its eggs hatch only during Spring tides. This singular knowledge led to proactive and effective control targeting the immatures (larvae). However, control of Ae. solliciants is threatened by recent changes in sea level and increased storms. This is primarily because mosquito control has also been based on decades-old technology for surveillance and on empirical data, rather than on basic principles underlying their occurrence. Our aim is to develop proactive strategies for control of both local and introduced vector species that will take into account changes in weather patterns and sea level, multiple introductions with differing genetic makeup, and the development of insecticide resistance and other forms of selection. We are testing new large-scale strategies to predict the occurrence and size of vector populations using eDNA, as well as NextGen based genetic models of dispersal and mathematical models of life-history.

Biology, Ecology, & Management of Emerging Disease Vectors

Director: Stephen Dobson
Start Date: 2015
University of Kentucky
NIFA Formula
1004542

Key points: mitigation strategies and surveillance; VBDs

Abstract: Despite ongoing extraordinary medical advances, infectious diseases are on the rise worldwide and account for a quarter of all human mortality and morbidity. Diseases once thought to menace only remote tropical inhabitants are now spreading everywhere, fueled by international travel. Dengue, chikungunya virus and other mosquito-borne pathogens can be deadly to humans and there are no vaccines or therapeutic drugs. Furthermore, new mosquitoes are also arriving, such as Ae. j. japonicus, a cold weather adapted mosquito that is becoming increasingly common in the urban and suburban USA (Kaufman & Fonseca 2014). While outbreaks of mosquito-borne arboviruses pose serious risks to the public, tick-borne diseases are the most common vector-borne diseases in the USA. Every year, there are over 20,000 confirmed cases of Lyme disease, and CDC has recently noted that this is likely a 10-fold underestimate. In addition, many new tick-borne pathogens have emerged in the past 20 years. Confirmed cases of human anaplasmosis (first described in the 1990s) now exceed 1000/year in the Upper Midwest, with an additional focus on the east coast. Other pathogens, while still rare, are also associated with rising incidence of human disease. The changing patterns of tick-borne disease reflect the fact that tick species (such as Ixodes scapularis and Amblyomma americanum) are expanding their range, and tick population sizes are increasing. Ecological changes, including increases in the populations of wildlife reservoirs, altered climate, and changes in forest and landscape features are clearly important contributing factors. In the near term, these changes will likely lead to an even greater burden on human health with continuing increases in Lyme disease as well as other tick borne infections. Encouragingly, important advances are being made in areas that include new methods and tools for monitoring and controlling mosquitoes and ticks. However, the budgets for research and abatement programs have been substantially reduced. Thus, improved information sharing and coordination will result in better decisions in applying the limited resources, standardization of monitoring and control tools and teams able to better compete for limited funding resources. The availability of vector resources (laboratory colonies, cell cultures, pathogen strains) are critical components for investigations to prevent the spread of pathogens by vectors. The aim of this project area is to support and promote available resources such as the BEI Resources established by the National Institute of Allergy and Infectious Diseases (NIAID) for human pathogens and to identify alternative sources for vector resources beyond those found in BEI.

Biology, Ecology, & Management of Emerging Disease Vectors

Director: Michael Kaufman
Start Date: 2015
Michigan State University
NIFA Formula
1004702

Key points: VBDs; surveillance

Abstract: The project seeks to build an interactive and interdependent network of scientific expertise to deal with expanding/invasive tick and mosquito species and mosquito-borne disease outbreaks. We will address these important issues via five objectives: (1) Development of parasitic arthropod catalogues and resources that help identify vectors and disease agents, (2) Develop new, integrated tick management and community-centered approaches, including understanding the biology and ecology of novel and emerging tick-borne pathogens, (3) Increase our understanding of Ae. albopictus (Asian tiger mosquito) and Ae. aegypti (yellow fever mosquito) populations with a focus on surveillance, range expansion, ecology, genetics, climate change and disease risk (4) Develop new vector control tools, including socio-ecological approaches, and (5) Provide a training framework and tools for developing scientists in the field of Medical and Veterinary Entomology. The project will affect all U.S. residents by understanding, assessing, and mitigating the threat posed by mosquitoes of public health importance. Further, we anticipate enhanced ability to detect and predict outbreaks of vectors and associated diseases. The project further provides for and encourages environmentally sound, scientifically-based, and professional control by mosquito control agencies. Since 2010, we have met and exchanged published and unpublished results and have vetted ideas from group participants. We are now ready to start developing collaborative proposals for federal funds. In addition, some of our activities, such as the development of an arthropod catalogue, will result in enhanced visibility on the availability of vector resources for human and animal pathogens.

Immunological and Abiotic Effects on Ectoparasite Population Dynamics

Director: J Owen
Start Date: 2013
Washington State University
NIFA Formula
213165

Key points: VBDs; cattle; ticks

Abstract: The Rocky Mountain Wood Tick (RMWT) is a common tick species in the western United States. The RMWT completes development by blood feeding on multiple species of animals (e.g. mice, rabbits, and cattle). The tick transmits multiple pathogens of importance to human and animal health. One example is the pathogen of cattle, *Anaplasma marginale*, which causes morbidity and mortality for cattle and is economically costly to cattle producers. The density and distribution of RMWT influences the transmission of *A. marginale*. Areas with more ticks experience higher rates of pathogen transmission among cattle. It is important to understand the factors that affect RMWT density/distribution in order to predict areas of risk for pathogen transmission. Currently the factors that control RMWT populations are poorly understood. Research in other tick systems suggests that host animals can acquire immunological resistance to tick blood feeding that impairs tick survival and fecundity. This natural anti-tick resistance may be an important factor controlling tick density and distribution. Ticks will be blood fed on hosts in the lab to control the history of tick exposure among the host animals. The recovered ticks will be placed in field enclosures to develop and oviposit. The success of development and reproduction will be compared between ticks from naive versus exposed (resistant) hosts at varying conditions of temperature and humidity. This information will be used to develop a predictive model for RMWT population dynamics in the field. Finally, tick populations will be monitored over time from field-trapped host species. This will provide data on actual tick densities that can be used to validate the predictive model. This project will produce a model that predicts RMWT densities and distributions, based on weather and host populations. This model can be used to estimate risk of RMWT exposure and pathogen transmission. Cattle producers and public health officials can use this risk assessment tool to make decisions about landscape use, or employing anti-tick measures (e.g. acaricides). In addition, this project will yield new data on the general importance of anti-vector immune defenses to pathogen transmission. This will improve a broader understanding of infectious disease. The results of this project will be reported in peer-reviewed journals. Any effective risk-prediction models for RMWT will also be reported to cattle producers, or other interested parties, through the WSU extension and outreach programs.