



2014

Division of Environmental Systems

Institute of Bioenergy, Global Climate Change, and
Environment



**Division of Environmental Systems Portfolio
Strategic Plan**

2014 Progress and Implementation Report

*USDA-National Institute of
Food and Agriculture*

Division of Environmental Systems Portfolio Strategic Plan

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NIFA's Division of Environmental Sciences (DES) created and continues to maintain the most diverse yet focused portfolio to address both competitive and noncompetitive environmental science, education and outreach across agriculture and natural resources systems. Forged from the expertise previously aligned with CSREES's Natural Resources and Environment (NRE) Unit and the Multidisciplinary Environment and Natural Resources (ENR) unit, DES combines at its core experts in air, water and soil with land use specialties in forest and rangeland watershed management, wildlife habitat, agriculture land conservation, and small business innovation.

The competitive portfolio, represented by the AFRI Renewable Energy Natural Resources and Environment Foundational, Water for Agriculture Challenge Area; National Integrated Water Quality; Soil and Water, Forests and Related Resources Small Business Innovation; Renewable Resources Extension Act National Focus Funds; and Forest Products Research programs results in a mix of funded research, engineering, technology, education and outreach in the natural, ecological and social sciences that continues to produce a better understanding of agricultural and natural resource (combined terminology is *agroecological*) processes. The DES portfolio formulates through its combination of more sophisticated yet applicable predictive models, technologies and decision support tools; challenges the agricultural science community in data management and sharing, and project evaluation; and continues to provide support for future scientists.

DES's funded portfolio provides a broad suite of impactful results that advance agricultural and natural resource sciences. Prime examples of the far-reaching nature of DES funded projects include:

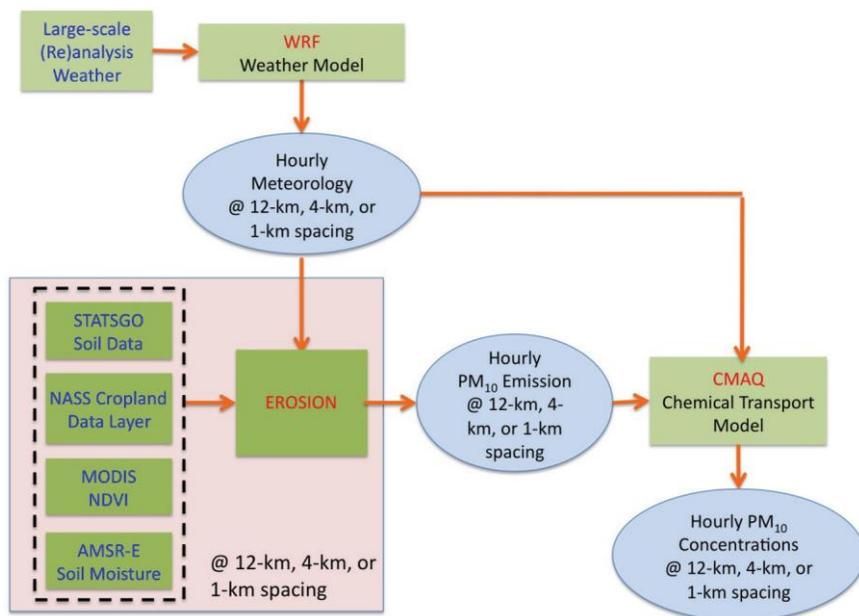
- *Incorporation of the Wind Erosion Predictions System (WEPS) Within a Comprehensive Regional Air Quality Model by Dr. Brian Lamb at Washington State University, Pullman.*

Their study focused on understanding the role of windblown dust from agricultural sources in regional air quality and to develop new capabilities for treating windblown dust within a comprehensive regional air quality modeling system. There were six major components of the study: 1) To adapt the WEPS model for use within the gridded Congestion Mitigation and Air Quality Improvement (CMAQ) framework, using gridded soil, land cover, and crop management databases; 2) To develop treatment of PMcoarse and PM2.5 (pm is particulate matter at the 2.5 micron diameter) emissions within the new WEPS module; 3) To apply the WEPS-AIRPACT (Air Indicator Report for Public Access and Community Tracking) system to the Sept 1999 Pacific Northwest (PNW) and other dust storms for evaluation purposes; 4) To implement WEPS within AIRPACT-3 for automated daily forecasts; 5) To evaluate WEPS using routine and enhanced dust

monitoring within the region for periods with high wind speeds; and 6) To document the use of WEPS within CMAQ as a basis for sharing the tool with the CMAQ user community.

In this work, Lamb used the EROSION submodel from WEPS as a PM10 emission module for regional modeling by extending it to cover the PNW on a gridded basis consistent with the domain used by their AIRPACT air quality forecast system. The new PM10 emission module was then employed within the AIRPACT system, a regional weather and chemical transport modeling framework used for comprehensive simulations of a wide range of pollutants to evaluate overall air quality conditions. This framework employs the Weather Research and Forecasting (WRF) weather model along with the CMAQ model to treat ozone, particulate matter, and other air pollutants. To demonstrate the capabilities of the WRF/EROSION/CMAQ dust modeling framework, we conducted simulations of dust storms that occurred in central and eastern Washington during 4 October 2009 and 26 August 2010. Comparison of model results with observations indicated that the modeling framework performed well in predicting the onset and timing of the dust storms and the spatial extent of their dust plumes. The regional dust modeling framework predicted elevated PM10 concentrations hundreds of kilometers downwind of erosion source regions associated with the windblown dust, although the magnitude of the PM10 concentrations were extremely sensitive to the assumption of surface soil moisture and model wind speeds. The results of this work will provide the basis for incorporation of the WEPS erosion module within the AIRPACT system on an operational basis.

Fig. 1--Flow diagram for incorporation of the WEPS EROSION submodel into a WRF-CMAQ air quality modeling framework: WRF = Weather Research and Forecasting, CMAQ = Community Multiscale Air Quality, STATSGO = State Soil Geographic, NASS = National Agricultural Statistics Service, MODIS = Moderate Resolution Imaging Spectroradiometer, NDVI = normalized difference vegetation index, and AMSR-E = Advanced Microwave Scanning Radiometer for EOS (Earth Observing System).



- *Development of an Early Warning System / Decision Making Tool for Regions Undergoing Droughts by Drs. Clyde Munster, John Nielsen-Gammon and Tom Cothren at Texas A&M University, College Station.*

Their study focuses on creating an Early Warning System/ Decision Making (EWS/DM) tool to forecast meteorological, agricultural, and hydrological drought to help agricultural producers and water managers' better plan and prepare for drought. There are three major components of this study, 1) field monitoring of crop stressors, 2) weather forecasting, and 3) hydrologic modeling. These three components will produce data that will be used in the EWS/DM tool to provide three month forecasts of weather and hydrologic conditions.

Field studies were conducted on drought triggers for cotton and corn over two years. The most important set of data collected for this portion of the project was the canopy temperature data from the remote infrared temperature (IRT) sensors. For both years, over 98% of the possible data was recorded. The unusually high rainfall in one year did not allow the crop to reach a "stressed condition", therefore, a clear separation in canopy temperature (CT) between irrigated and dryland plots was not observed. During 2013 however, a clear separation in CT was observed throughout most of the season, and indicates that plants will use available soil moisture to maintain a lower CT. In year 1 CT was a good indicator of photosynthetic activity, whereas in year 2, it was not. Field data collection was continued this year. Precipitation and temperature data is forecasted with a three month lead time. Past weather data will be used to produce a probabilistic range of future conditions. A three month forecast will be produced for "wet", "mid", and "dry" moisture conditions to provide the range of conditions that will be used in the hydrologic model. The Soil and Water Assessment Tool (SWAT) will be used to forecast the hydrologic conditions that will be used in the EWS/DM. The Upper Colorado River Basin (UCRB) in West Texas was used as a case study. SWAT was calibrated and validated for both weekly average streamflow and annual cotton yields with satisfactory results. The model produces various parameters including, but not limited to, biomass production, evapotranspiration, soil moisture, and streamflow. Several forecasted weather scenarios were run in the model to provide a range of forecasted hydrologic conditions.

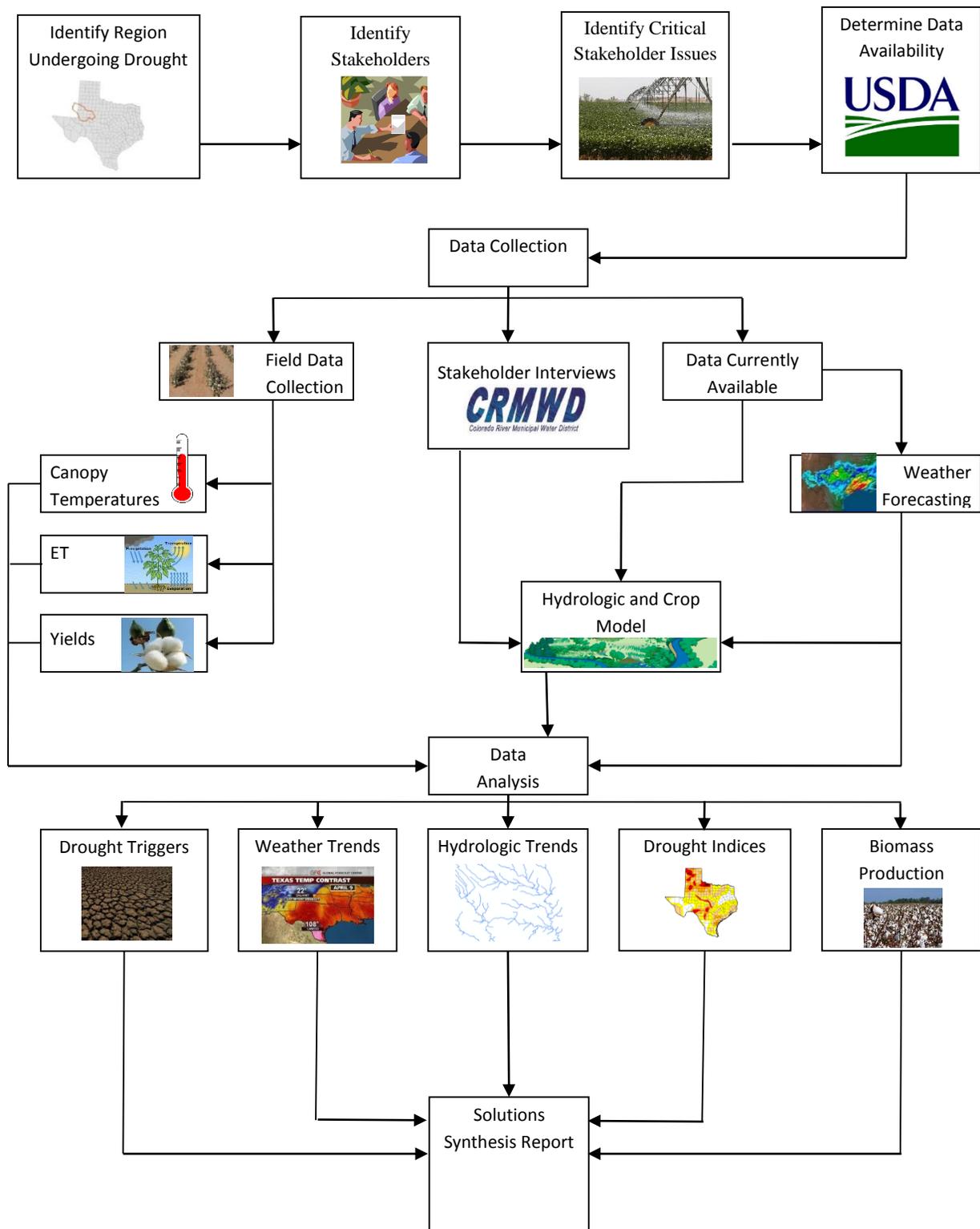


Fig. 2-- Flowchart for the EWS/DM tool.

The NIFA Environmental Systems portfolio is a major contributor to solutions of air, water and soil issues on agricultural, forest and rangeland watersheds through its vision and mission:

Our DES mission is ***sustaining the Nation's working lands through scientific leadership and management of public investments in soil, water, air, and ecosystems.***

Our DES vision is ***providing scientific leadership, accountability, and collaboration to sustain the Nation's working lands and environment.***

Fiscal year (FY) 2010 was the first year that AFRI solicited competitive grant applications for the Renewable Energy, Natural Resources and Environment (RENRE) program under the Foundation area. The first RENRE solicitation entitled Agricultural Water Sciences requested applications in FY 2010 to addressing drought triggers and chemicals of emerging concern (CECs) in recycled water used to irrigate crops eaten fresh. The FY 2011 RENRE program solicited applications in three areas, *Processes and Transformation in Soil, Water, and Air, Thresholds in Agroecosystems and Management in Agroecosystems*. No solicitation was published in FY 2012. In FY 2013, RENRE focused on the understanding of fundamental soil, air, and water processes in actively managed agroecosystems, rangelands, and/or forests especially in areas potentially impacted by more frequent and severe droughts and/or floods. Funding was directed towards the evaluation of the physical, biogeochemical (including microbial), and/or coupled (e.g., nitrogen coupled with soil carbon) processes affecting the flow, fate and transport, transformation, movement, and storage of either nitrogen and phosphorus, implicated as both downstream and/or atmospheric pollutants; or chemicals of emerging concern (CEC) in recycled, drainage, and runoff water with the potential to be used for irrigation. Relevant CECs were defined to include those from animal and human waste pathways that are of environmental, human health, and/or food safety concern (e.g., human drugs, veterinary drugs, antibiotics, hormones). In FY2014 RENRE, newly termed the Bioenergy, Natural Resources and Environment (BENRE) by the Agricultural Act of 2014 (2014 Farm Bill) requested applications for nitrogen and phosphorus cycling, that address management practices and/or processes across soil-air-water interfaces that will lead to substantial improvements in nutrient use efficiency or improvements to impaired natural resources within a managed agroecosystem with the potential for high-risk/high reward projects that demonstrate a transformative approach to the problem; and agroecosystem management, projects that connect biodiversity specifically as an ecosystem service to production system functionality, productivity, socioeconomic viability, sustainability and the production of other ecosystem services related to air, water, soil, habitat and land use. In FY2014 a new challenge area entitled *Water for Agriculture* focused on regional issues integrated across research with research/education- or research/extension and restricted to Coordinated Agricultural Projects (CAPs) only. DES Program requested proposals that focused on sustaining water quantity, quality, and availability for agricultural use while maintaining environmental quality through 2050 as specified by the following questions:

- How will altered frequency and intensity of drought, flooding, temperature, etc., land use; and industrial and consumer demands affect the quantity, quality, and availability of water for agricultural use? How can agriculture adapt to these changes?
- How can the quality of water for agricultural use be sustainably improved?

- How can sufficient water supply for agricultural use be achieved in consideration of competing demands? How can production practices be adapted to be more water-use efficient, conserving, and less polluting?
- What scientific information is necessary for appropriate institutional, policy, regulatory, and governance decisions that will ensure regional agricultural water security to meet diverse and conflicting needs?
- How will new knowledge be delivered to agricultural and nonagricultural water users to understand the problems or issues being addressed and actions necessary to identify appropriate solutions for these problems?

NIFA's Environmental Systems Portfolio contributes significantly to the mission of USDA to provide leadership on agriculture production, natural resources management, food security, food safety, climate and bioenergy-related issues based on sound decision making and public policy, the best available science, and properly applied management. Its goal is to develop sustainable agriculture, rangeland and forestry based strategies in rural and urbanizing systems through the appropriate expenditure of public funds for:

1. Improved knowledge and capabilities through AFRI Foundational, NIWQP and Forest Products Research (FRP) competitive research in air, water and soil sciences as they relate to agriculture and natural resources.
2. Institutional support, long-term and high risk research accomplished with Hatch capacity funding (42% of the DES Portfolio) with highly limited pre-and post-award management capabilities;
3. Environmental Science Education and Extension--Increase the number of agricultural, environmental and natural resource scientists, educators and extension professionals in the workforce with the skills and knowledge to address societal issues and improve the understanding of environmental systems, land use changes and impacts and options for sustainable food production and environmental stewardship. These activities are accomplished through both capacity funding—Smith Lever (b) and (c) (20% of the DES Portfolio, limited pre-and post-award management potential) and competitively funded and integrated NIWQP (<23% of the DES Portfolio, greater post-award management potential), capacity and competitive renewable Resources Extension Act (RREA) funds and AFRI (23-30% of RENRE, greater post-award management potential).

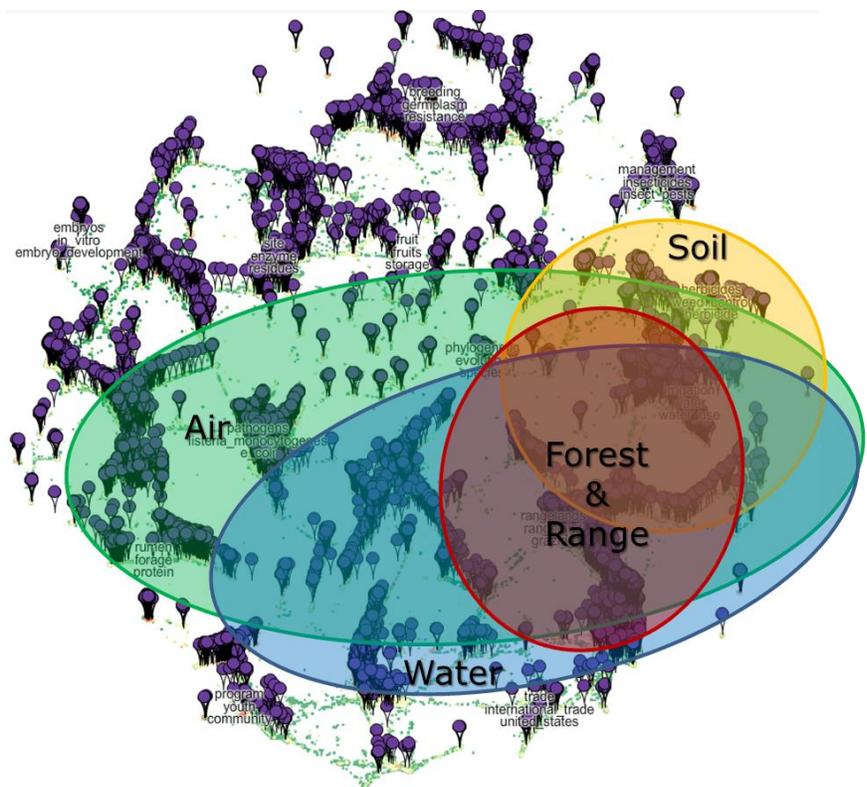
The DES portfolio emphasizes three components necessary for the development of agroecosystem services, the foundational building blocks of agriculture, air, water and soil:

Air: As agricultural producers face regulatory pressures related to air quality, DES seeks to provide sound science to protect the environment while maintaining a viable production system. Research activities develop emission data and improve measurement, control, and transport of odor, gases and particulate matter. Outreach activities include transferring technologies and best practices to producers and regulators to reduce pollutants and greenhouse gases.

Water: U.S urbanizing communities and rural areas depend on a safe and reliable water supply. The science and management of water requires consideration of the quantity and quality of water resources and the land-management activities that affect these water resources. Through research, education, and extension, DES's water programs provide basic knowledge, application and learning opportunities needed to address agricultural water quality and quantity issues.

Soil: Soils profoundly affect agricultural productivity and sustainability, ecosystem stability, and global change. Soils provide physical support, water, air, and nutrients for plants, and they receive natural and man-made materials and wastes. At the same time, soils contain an immense diversity of microorganisms, plants, and animals. This dynamic combination of life, water, nutrients, and minerals can remove and transform harmful products while storing and recycling water, nutrients, and other elements needed for sustainable agriculture and natural resources.

Linking all three essential components of agroecosystem services, and of increasing concern to the Environmental Systems portfolio, is the topic of reactive nitrogen. Excessive reactive nitrogen compounds in the environment are associated with many large-scale environmental concerns, including eutrophication of surface waters, toxic algae blooms, hypoxia, acid rain, nitrogen saturation in forests, fine particulate in the atmosphere and global warming. NIFA has made significant investments in this topic over the years in many of our programs. Most recently, the AFRI RENRE program in 2013 and 2014 has had a priority that focused on nutrients and the cycling of reactive nitrogen.



FiFig. 3--A map of all NIFA science (small dots) using the new Pushgraph™ tool. The large purple pushpins are USDA projects (14,512) over a 12-yr period from the REEIS database that deals with the topic of reactive nitrogen inferred to the NIFA science map. The ovals demonstrate the extent of air, water, soil, and forest and rangelands in

the portfolio and the portfolio's relationship to the topic of reactive nitrogen across USDA.

From 2003-2009 the NRI/AFRI air quality program as well had significant investments in this topic. However, reactive nitrogen cuts across all subject areas in the Environmental Systems portfolio and across NIFA and USDA (Fig. 3). A recent report by the Integrated Nitrogen Committee of EPA's Science Advisory Board (SAB) has made several recommendations that involve U.S. agriculture. The SAB recommends that reactive nitrogen losses to the environment should be decreased by 25% overall in the US. Agriculture will play a significant role in meeting this goal since more than half of the reactive nitrogen is fixed by agriculture each year. The nutrient cycling priority in the AFRI RENRE and BENRE programs will directly contribute to this goal and is focused on transformative science to reduce the loading of reactive nitrogen to the environment while increasing nitrogen use efficiency in agricultural production systems.

The SAB reactive nitrogen report also recommended that coordinated federal programs could better address reactive nitrogen concerns and help ensure clear responsibilities for researching and managing reactive nitrogen issues. The SAB recommended that EPA convene an interagency reactive nitrogen management taskforce. An interagency taskforce was convened in January of 2014. A workshop was conceived and held by the taskforce in July of 2014 to evaluate the roles of USDA, EPA, and USGS on the topic of reactive nitrogen. An inventory of research was created for each of the agencies and an analysis is being performed over the next year to determine what has been done, where research gaps exist, and the most efficient areas of scientific focus to decrease reactive nitrogen to the environment. The nitrogen projects identified in Fig. 3 are USDA's contribution to the joint database and significant effort by NIFA will be expended to evaluate NIFA's investment and measurable impacts on the reactive nitrogen topic over the last decade.

This report provides information on progress made towards the set of outcomes described by indicators in the Environmental Systems Portfolio plan. It includes a mix of accomplishments through efforts of NIFA staff associated with the portfolio, and accomplishments of the funded projects of the portfolio:

1. New technologies and management practices (TMP): technologies and management practices developed to mitigate emissions, improve production, etc.;
2. Models validated (MV): new or existing models that have been validated (proven to work in a given sector) in one or more new sectors that can potentially lead to change in a community;
3. Economic analyses (EA): demonstrated positive economic response to a performance measure that can monetarily incentivize adoption of a performance measure;
4. Knowledge impact (KI): new methods or a transformative line of new science that will transform a science community;
5. Education impact (EI): an education event that will transform communities or meet gaps in trained scientists for specific science communities.

Examples of Staff Accomplishments: Some of our significant accomplishments by staff in DES included the five-month efforts of two National Science Foundation (NSF) IGERT (integrative graduate education and research traineeship) student PhD Fellows, focused on nitrogen policy. These IGERT Fellows assisted in searching the USDA portfolio of grants on nitrogen and the environment. As an environmental concern in soil, water, and air, the students analyzed 14,500 projects on this topic from FY 2000-2012 from both the competitive and capacity funding lines. Using a classification algorithm focused on word association entitled *topic modelling*; they demonstrated provocative links among DES topics. Data was graphically displayed on dot maps and shared at a national EPA/USGS/USDA workshop co-hosted by another DES staffer, to identify gaps, collaborations, and future strategies. This work came to the attention of USDA’s Under Secretary for Research, education and Economics (REE) who developed an interest in common international collaboration opportunities and gaps for future REE work. The IGERT Fellows further analyzed livestock and nitrogen as air emissions and manure management using additional keywords resulting in an analysis of 11,400 projects. From this application of topic modelling, dot sets and apparent relationships clearly demonstrated research, education and extension gaps and the subsequent need for NIFA institutes to collaborate on environmental issues invoking better animal genetics, nutrition and economic management to manage environmental risks in agriculture and to highlight the potential for efforts to prevent and or “clean up” soil, water and air degradation. Geographic maps were produced from these analyses that show where most of the nitrogen research occurred. In some cases, critical levels of pollution were occurring in states that did not have adequate research, so geographic or regional targeting to meet environmental needs or respond to

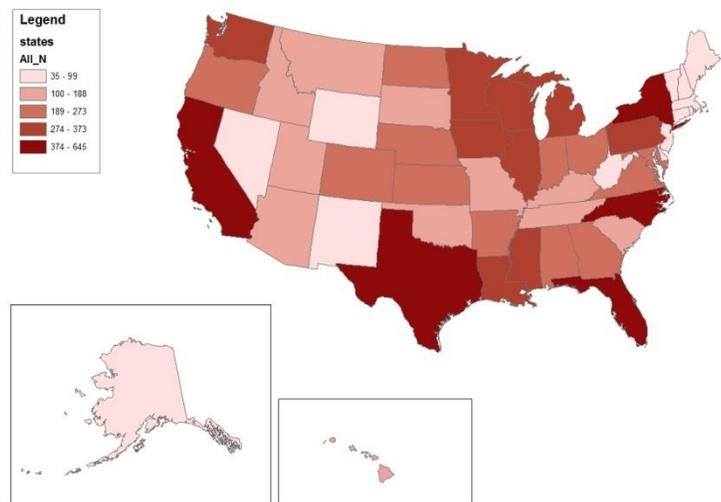


Fig. 4-- Geographic gaps (lightest color) where NIFA has few studies on reactive nitrogen as identified by VosViewer topic modeling.

local climate conditions such as snow and frozen ground, irrigation or high rainfall also is needed. Further analyses included mapping the broader topic of environmental health and how it intersects with human, animal, plant and economic health. Having dedicated staff like the IGERT Fellows to assist with project analysis is critical to program synthesis by identifying research and geographic gaps, important collaboration potential with other NIFA institutes,

partnership opportunities across government and internationally to improve DES's documentation of outcomes, impacts and successes.

NIFA also hosted Rosenthal Fellow Tschuna Gibson from American University who is conducting an assessment of Traditional Ecological Knowledge (TEK) of Native Americans in land and water management through NIFA grants as well as other USDA and federal agencies. She completed a CRIS search of NIFA projects and is interviewing NIFA and other agency staff to determine a baseline of these activities and future needs on tribal lands.

DES staff co-wrote and edited text that will be used for a new initiative pushed by OSTP in water; a DES forestry staff member was the coordinating lead author for "Changing Philippine Climate: Impacts on Agriculture and Natural Resources", the final publication of a workshop that brought an integrated perspective to a wide variety of issues concerning causes, effects and impacts of a changing regional climate. A Workshop Report is in process to summarize the findings of the EPA-USDA-USGS Working Meeting on Management Strategies for Reactive Nitrogen and Co-Pollutants to be published in a special issue of *Environmental Science & Technology*. Staff helped steer the development of "Drawing Down N₂O to Protect Climate and the Ozone Layer: A UNEP Synthesis Report." United Nations Environment Programme (UNEP), Nairobi, Kenya (2013).

Examples of Partner Accomplishments: Major accomplishments by DES funded partners included the findings of Hatch Accession Number 1003568 that developed new soil moisture mapping and upscaling approaches for large-scale *in situ* sampling networks. This Hatch project is using new cosmic ray soil moisture observing systems linked to satellite, radar, soil sensors, and rain gauges to provide more accurate soil moisture in Oklahoma at the 9-40 square km scale. This activity will correlate to the European space agency and the new NASA soil moisture satellites.

NIFA-DES supports cover crops through a Hatch multi-state committee, SARE competitive grants and sub-goals of other research grants such as the sustainable corn project. This year a national forum was held with 300 live attendees and 230 remote forum locations. Currently an estimated 2-3 million acres out of 200 million acres of row crops are using cover crops. Cover crops improve the soil health by increasing water use efficiency, reduce nutrient and soil loss, and reduce runoff to surface and groundwater. Deep rooted cover crops build soil organic matter that can store up to 25,000 gallons of water per acre. It can reduce soil compaction and increase microbial activity. Legume cover crops add additional nitrogen for later crop use.

Addressing Air, Water and Soil Issues in Agricultural, Forest and Rangeland Ecosystems with Competitive Funding:

AFRI-BENRE. Producers, land managers and decision makers need greater understanding of fundamental soil, air, and water processes in actively managed agroecosystems, rangelands and forests especially in areas potentially impacted by more frequent and severe droughts and/or floods. In FY 2014 scientists were encouraged to address management practices and/or

processes across soil-air-water interfaces that will lead to substantial improvements in nutrient use efficiency or improvements to impaired natural resources within a managed agroecosystem with the potential for high-risk/high reward projects that demonstrate a transformative approach to the problem of excess nitrogen and phosphorus cycling, that; or to address agroecosystem management with projects that connect biodiversity specifically as an ecosystem service to production system functionality, productivity, socioeconomic viability, sustainability and the production of other ecosystem services related to air, water, soil, habitat and land use.

Projected Outcomes: BENRE will model promising agricultural systems that have balanced human social needs with natural systems to produce more food in more sustainable ways, and contribute to use-inspired foundational research that adds to the understanding of sustainable production of agroecosystems while retaining needed ecosystems services. Sustainability implies the interactions among—societal, economic, and environmental dimensions working across disciplines, looking long term across multiple scales, understanding responses in terms of resilience and adaptation, and on the synergies among responses. This program anticipates funding projects that reflect diverse spatial and temporal scales across geographic diversity. Specific to nitrogen and phosphorus cycling, projects will offer foundational research that supports decision-support tools for assessment of ecosystem services like the following: 1) Predictive and/or hind-casting tools to assess control technologies to mitigate nitrogen and phosphorus movement or impairment; or 2) Improve process-based models to analyze nitrogen and phosphorus life cycles in agroecosystems, rangelands, and forests. Specific to the agroecosystems management priority, projected outcomes include Agroecosystem projects designed to develop management systems that significantly increase the output and/or value of at least three ecosystem services compared with the current management system for the region.

Accomplishments: NIFA will award approximately 18 research projects (~9 million dollars) that focused on soil, air, and water processes in agroecosystems (see Appendix A).

AFRI-Water Challenge Area. In FY 2014, NIFA-DES initiated a new challenge area to address critical water resources issues such as drought, excess soil moisture, flooding, quality and others in an agricultural context. Current drought conditions in the West, as well as drought conditions across the country in recent years, make the initiation of this new challenge area particularly timely. Continued significant variations from the historical rate of water supply, demand and quality are projected to have major impacts on agricultural, forest, and rangeland production systems. This new program area is coordinated with and leverages effort in the Agricultural Production and Climate Change and Sustainable Bioenergy challenge areas, and helps solve critical water problems in agricultural, rural and urbanizing areas across the United States. The program focuses on developing solutions for water management that link food, water, climate, energy, and environmental issues. Funding will be used to develop management practices, technologies, and tools for farmers, ranchers, forest owners and managers, public decision-makers, public and private managers and citizens to improve water resource quantity and quality. NIFA-DES's approach links social, economic, and behavioral

sciences with traditional biophysical sciences and engineering to address regional scale issues with shared hydrological processes, and meteorological and basin characteristics.

Projected Outcomes: Increased or sufficient water availability, quantity, and quality to meet agricultural needs while maintaining or improving the natural, economic, and social environments. The AFRI Water Challenge Area requested proposals that lead to solutions for U.S. water challenges related to the production of food, fiber, fuel and other agricultural goods and services. These solutions must simultaneously maintain or improve environmental conditions and be feasible across a broad spectrum of producers, industry, consumers, etc. The impact will be to change, as appropriate, agricultural, consumer, and policy actions to improve the availability, quantity, and quality of the water supply for the next several decades or more. Several approaches may be appropriate, e.g., changes in production practices and management decisions, technological innovation for water usage and conservation, scientifically informed policy decisions or governing institutions, and improved projections of changes to supply, demand, and use of this resource.

Accomplishments: NIFA will award approximately five Coordinated agricultural Projects (@ \$1 million per year for five years) at the regional scale and several conference, sabbatical and seed grants at smaller scales (~6 million dollars) that focus on agriculturally related water issues (see Appendix B).

Section 406-NIWQP. NIFA's NIWQP funds research, education and extension to expand and/or elevate existing, and encourage new, federal partnerships to promote water conservation at watershed, landscape, and regional scales in agricultural, rural, and urbanizing communities, and reduce the impacts of climatic disturbances. The Program supports integrated activities that will foster a watershed/landscape-scale approach that encourages place-based agricultural water management and sustains U.S. natural resources, agriculture, and rural communities in the face of competing water demands. In FY2014 the NIWQP is focused on funding the synthesis of ten years of competitive- and capacity-funded NIFA water quality and quantity funding across the U.S. The NIWQP also focused on reducing drought impacts on agriculture and promoting drought preparedness through the recognition of threshold indicator values that tie the levels of drought severity with appropriate responses to maintain agricultural production. These indicators or triggers are used to determine drought aid and eligibility. Sustainable production under highly variable moisture conditions requires readily understandable, scientifically sound drought triggers at appropriate temporal and spatial scales and specific to local production systems and conditions. Applicants were directed in FY2014 to develop the science behind the most appropriate drought triggers and provide an understanding of the connection between trigger levels and drought management responses or decisions. Applicants could choose to aid decision making so as to optimize the allocation of water use between productive and environmental uses. Optimal use of water would simultaneously consider the nexus of the environment, ecosystem services and the demands of associated urbanizing lands and agriculture.

Projected Outcomes: NIWQP should improve the quality and conservation of our Nation's water resources through research, education, and extension activities. Projects funded through this program will work to develop a trigger or triggers to aid science based management decisions, practices and/or responses with broad applicability across the states and territories of the U.S. Or, projects should provide estimates of the economic value of water across different uses. *In toto* this program will help solve water resource problems by advancing and disseminating the knowledge base available to agricultural, rural, and urbanizing communities. Funded projects should lead to science-based decision making and management practices that improve the quality and quantity of the Nation's water resources in agricultural, rural, and urbanizing watersheds.

Accomplishments: NIFA awarded seven integrated projects (~4 million dollars) that focused on watershed-scale projects that focused on conservation and effects of water resources to meet water availability issues from drought or understanding the value of water in water use decision-making (see Appendix C).

Forest Products Research (FPR): Because of the lack of FY2014 funding, we will report updates to the FY2013 funded projects in this portfolio report. This Forest Products Research (FPR) Program is authorized and funded by Congress in the FY 2013 Appropriations as a special research grant to be awarded competitively. The intent is to stimulate the generation of new knowledge and to transfer technologies that are necessary to balance the sustainable use of U.S. forest resources to maintain a vigorous, globally competitive domestic forest products industry. It is specifically designed to respond to current and emerging wood utilization issues, create new and improved value-added products, and provide technical information for the production of cross laminated timber from our Nation's wood supply which is critical to the sustainability of the national economy (see Appendix D).

Projected Outcomes: The FPR is designed to stimulate the generation of new knowledge and to transfer technologies to maintain a vigorous, globally competitive domestic forest products industry. The FPR is uniquely intended to address the varying needs and opportunities of the different regions of the country but within a national needs framework. It is specifically designed to respond to current and emerging wood utilization issues, create new and improved value-added products, and provide technical information for the production of cross laminated timber from our Nation's wood supply, critical to the sustainability of the national economy.

Applications were solicited for the FY 2013 appropriation under the following special research areas:

1. Innovative solutions to develop new industries/technologies that can optimally process/utilize large quantities of pest-damaged or -killed trees;
2. Developing grade and size models for conifers (Southern, Western, Northern, etc.);

3. Promoting use of low value hardwoods for prime bio-products/value-added utilization of underutilized hardwoods;
4. Developing structural composites, such as, Cross Laminated Timbers (CLT) and others using softwoods.
5. Thermal modification of hardwood and softwood lumber.

Accomplishments: The application solicitation attracted 32 very competitive proposals and five integrated projects were successfully funded (~1.3 million dollars), three of which were on cross laminated timber (see Appendix C) with other forest product priorities that included innovative solutions to develop new industries/technologies that can optimally process/utilize large quantities of pest -damaged or -killed trees; developing grade and size models for conifers (Southern, Western, Northern, etc.); promoting use of low value hardwoods for prime bio-products/value-added utilization of underutilized hardwoods; developing structural composites, such as, Cross Laminated Timbers (CLT) and others using softwoods; and thermal modification of hardwood and softwood lumber.

The funded projects (4 were rated outstanding) were:

1. Development of Novel Hybrid Cellulose Nanocomposite Film With Potent Biocide Properties Utilizing Low Quality Appalachian Hardwoods;
2. Technical Assessment of Cross Laminated Timber from Northeastern US Forests;
3. Nonlinear micro-mechanics and failure analysis of wood adhesive bonds
4. Hybrid CLT Panels for Sustainable Building Solutions;
5. Next Generation CLT: Mass-Customization Of Hybrid Composite Panels.

Addressing Air, Water and Soil Issues in Agricultural, Forest and Rangeland Ecosystems with Examples of Non-competitive Capacity Funding, RREA and M-S

Renewable Resources Extension Act (RREA). The Renewable Resources Extension Act of 1978 (P.L. 95-306) strengthened existing Extension programs by mandating and funding an expanded role for Extension in renewable natural resource conservation and management. RREA provides forest and rangeland owners and managers with information they need to sustainably produce wood products, forages and livestock, fish and wildlife populations and outdoor recreation opportunities. In addition to the benefits provided by a healthier environment and a more productive land base, the processors and consumers of these resources are served directly by RREA programs that foster the efficient use and distribution of forest and rangeland products.

Outcomes: RREA serves a broad array of forest and rangeland stakeholders, including landowners and managers, natural resource professionals, forest products industry, range-based cattle industry, and non-consumptive. RREA programs support efficient resource utilization and products marketing, provide products to consumers, and promote returns on investments of landowners, processors, and users. The sustainability of the nation's forest and rangeland resources is largely dependent on the actions of millions of private forest owners, farmers, ranchers, and land managers. RREA is contained in the 2008 current farm bill and was extended through FY2013. Annual authorized funding level: \$30 million.

Accomplishments: RREA is a capacity program that in FY2014 provided funding (\$4.060 for extension programs in forest and rangeland resources to 72 land-grant institutions (51 1862's, 17 1890's, and three territories – Guam, Virgin Islands, Puerto Rico). The current RREA Strategic Plan, FY 2012-2016 includes four strategic issues with nine cross-cutting issues; seven issues are focused on DES portfolio topics and two issues, climate variability and biomass for energy are shared with the Divisions of Global Climate Change and Bioenergy, respectively. Additionally, approximately \$300,000 is awarded to land-grant institutions to carry out National Focus Fund projects. The RREA nationwide impacts based on the most recent program reporting data (FY 2013) are indicative of the outputs, outcomes, and impacts that the RREA institutions are having. Examples include:

- Forest and Rangeland Water and Wetland Resources
 - Number of new acres under management for wetland resources on private lands – 59,800
 - Number of new acres under management for wetland resources on public lands – 36,200
- Forest Stewardship and Health
 - Number of direct and indirect contacts who increased awareness of forest stewardship practices – 2,458,278
 - Number of direct contacts who increased knowledge of forest stewardship practices – 565,635
 - Number of forest landowners and managers trained to develop forest stewardship plans – 233,375
 - Number of forest stewardship plans initiated, supported or developed with Extension involvement – 51,710
 - Number of forest landowners who implemented at least one new forest stewardship practice – 32,058
- Rangeland Stewardship and Health
 - Number of direct contacts who increased awareness of vegetation management, water management, and animal management on rangelands – 318,204
 - Number of direct contacts who increased knowledge of vegetation management, water management, and animal management on rangelands – 18,531
 - Number of acres on which rangeland management was improved – 7,347,533

- Program Examples
 - Water Quality – University of Tennessee Extension conducts two programs, “Tennessee Healthy Hardwoods” and “Log-on Before You Log” to provide educational programs and materials to family forest owners and loggers to facilitate forest management planning and the protection of water resources through the use of best management practices (BMP) during logging operations. The Log-On program site that 97 percent of visitors owned forestland totaling 83,912 acres and 94 percent indicating that they would implement forestry BMP’s.
 - Rangeland Stewardship and Health – Several western states conduct programs using RREA funds. University of Wyoming conducts a “Wyoming Women in Range” program to increase the participation of women in rangeland management; in 2013 the program engaged 30 women. Additionally Range Management Schools involved 2,705 individuals who learned about assessment and monitoring, water quality and hydrology, and irrigated pasture management. University of Arizona utilizes RREA funds to support an award-winning “Reading the Range” program that encompasses 1.23 million acres. A Global Rangelands suite of websites provides a library of information on all rangeland topics. In 2013 approximately 3,900 new records (content) were added to the site, four videos were produced, and over 13,000 people visited the sites in FY 2013. University of Nebraska conducts a “Drought Risk on the Ranch” professional development program to assist ranchers in adopting management practices that minimize drought risk.
 - Forest Stewardship and Health – Cornell University conducts the “ForestConnect” webinar series. In FY 2013 average participation per webinar was 108 people representing 15 states and owning or managing slightly more than 430,000 forested acres. Total impact for FY 2013 was 972 participants owning 3.9 million acres. University of Pine Bluff taught a session on “Timber Theft on Private Land” at the Southwest Arkansas Small Farm Conference. A forestry workshop at the Annual Rural Life Conference in Pine Bluff was attended by 300 individuals who learned about forest management planning and timber marketing and harvesting. Washington State University continues to conduct a “Forest Stewardship Coached Planning” program in which family forest owners develop a forest management plan for their forest and receive support and coaching from professional foresters. In FY 2013 88 families completed the eight-week course and 105 forest stewardship plans were prepared.

Small Business Innovation Research (SBIR)

USDA Small Business Innovation Research (SBIR) supported a new grant company called Forest Concepts in the state of Washington which developed a wood straw mulch that reduced soil erosion by 98 percent. Since 2006 they have sold more than 14,000 tons of this bio-based product to the U.S. Forest Service, Bureau of Land Management, national, state and local parks and state transportation departments. The wood straw product was used on over 30 post wildfire sites to control erosion. They have licensed their process to Mountain Pine

Manufacturing, Inc. to produce erosion products from beetle-killed trees in Colorado. The product is heavier than crop straw mulch, is weed free and will not blow away. It is effective on slopes up to 70 percent. (See Appendices for further details).

McIntire-Stennis Accomplishment (MS)

This MS program supports on average roughly 200 new projects every year. Some of its recent accomplishments include:

1. Low nutrient availability limits growth rates on many forest plantations in the southeastern United States. North Carolina State University 's nutrition research on southern pine plantations including weed control and tillage has established prescriptive fertilization rates. Over 1.5 million acres of southern pine plantations are now fertilized annually. One year of fertilization results in the production of at least an additional 30 million tons of southern pine wood. This translates into additional revenue of \$316 M (Based on 2014 Southeastern Average Stumpage Prices for Pine Pulpwood of \$10.54/ton). Diagnostic tools, prescriptions, and response information are now available and play a key role in the adoption of and wise use of fertilizers as a silvicultural tool.
2. The Japanese recently introduced a program called the Wood Use Point Program (WUPP) that provided up to 600,000 yen (~\$6,000) in direct subsidies to home builders who used local wood rather than imported wood to build their houses. An economic analysis by CINTRAFOR (University of Washington) found that excluding US Douglas-fir wood products from the WUPP could cost US forest products manufacturers and exporters between \$30 million and \$ 40 million in lost exports during the implementation of the WUPP program. . However, in order to comply with WTO trade regulations, they provided a mechanism whereby imported wood could be classified as "local wood" if it met three criteria: 1) it was legally harvested, 2) the forest inventory of the wood was increasing over time, and 3) the imported wood contributed to the economic well-being of rural, fishing and mountain communities.
3. With McIntire-Stennis funds, support of the US Embassy in Tokyo, and the Japan Director of the Tokyo Office of the Softwood Export Council, CINTRAFOR researched and developed a report demonstrating that US Douglas-fir wood products met the three criteria developed for gaining recognition as "local wood" in Japan.
4. Following the December 17th (2013) meeting of the Corporation for the WUPP Fund, it was determined that US Douglas-fir wood products did meet the criteria laid out in the WUPP program and as a result, US Douglas-fir was formally recognized as a "local wood" within the WUPP program. The US was the only country that gained the "local wood" designation for their wood being imported into Japan. As a result, the US was able to save a \$30M Douglas-fir export and the US wood exporters are able to not only maintain

their access to the Japanese market but they have an opportunity to expand exports at the expense of other competitors.

- Another important result of the McIntire-Stennis program is the extent to which federal funds are leveraged with non-federal funding at a magnitude of \$1 Federal funds to \$7 state funds.

Activities: Many of the projects have created websites or social media outlets that contain information on nitrogen and phosphorus issues, advances in chemicals of emerging concern and water and watershed research, education and extension. Existing projects were highlighted at the Soil and Water Society annual meetings in Reno last July and new projects were introduced at the Project Director’s meeting held in Washington DC, July 2014.

DES Portfolio Activities:

Table 1. Revised Projected Timeline of DES Portfolio Activities

	2014	2015	2016	2017
Prepare an Environmental Sciences Strategic Plan for NIFA	X	X	X	X
Expand National Program Leadership Areas to Address DES Issues	X	X	X	X
Continuous Assessment through Post-award Management of Environmental Systems Research, Education and Extension Projects to Identify Science Gaps	X	X	X	X
Establish a Water Challenge Area and National/Regionally-focused Coordinated Agriculture Project under the Agriculture and Food Research Initiative (AFRI) for <i>Water In Agriculture</i>	X	X	X	X
Review and Re-establish the Core Set of Environmental Systems Portfolio Priorities	X	X		
Compose an External Advisory Group on Soil, Air and Water on Rangelands and Forest Systems	X	X		

Appendices of Awards for Air, Water and Soil in Agricultural, Forest and Rangeland Ecosystems

A. AFRI-BENRE Awards FY2014 (unavailable at this time, still in the decision-making process)

B. AFRI-Water Challenge Area Awards FY2014 (unavailable at this time, still in the decision-making process)

C. NIWQP Awards FY2014

1. Timothy Gates, PD, Colorado State University, Fort Collins, Colorado 80523

Water Quality and Productivity Enhancement In An Irrigated River Basin Through Participatory Conservation Planning And Analysis

Two great challenges to the nation's highly productive irrigated lands are salt and pollutant build-up in surface and groundwater, with consequent damage to crop yields and the environment, and growing urban competition for water supplies. Improved conservation practices, including schemes such as rotational lease-fallowing for preventing permanent dry-up of irrigated lands, can sustain productivity and benefit the environment by lowering return flows and pollutant loads to streams and aquifers while allowing continued access to irrigation water. A major obstacle to using these methods in western irrigated river valleys is the requirement that altered stream flow patterns cannot violate water rights or interstate river compacts. Finding river-reservoir system management schemes and economical ways to enhance water quality, boost productivity, and conserve water while complying with water law, require collaborating with water users and agencies to implement computational tools built upon comprehensive data. This project's goal is to identify and rank conservation practices, with extensive advisory stakeholder and student participation in model building and application processes, for sustaining the valuable agriculture sector in Colorado's Lower Arkansas River Basin by reducing salinity and selenium, increasing the productivity and economic viability of the land and its rural communities, and maintaining access to irrigation water. Calibrated regional and basin scale models are used to find effective conservation scenarios in a characteristic irrigated basin that satisfy socioeconomic and institutional constraints. Access through a web-based platform, documents and conference presentations, and course material will promote a vehicle for regional interaction and dissemination of findings nationally.

2. Kelly A. Grogan, PD, University of Florida, Gainesville, FL 32611

Innovative Policies to Optimize the Allocation of Water Quality and Conservation Investments and Maximize Multiple Benefits

This project focuses on the Lower Suwannee and Santa Fe River Basin (LSSFRB) in northern Florida. We propose to estimate the economic value of water in agricultural and in-stream (recreational) uses by examining the feasibility of a market-based payment program for ecosystem service provision. The basin's large recreational user base provides an opportunity to transfer benefits from users to those who undertake water quality/quantity investments. Changes in on-farm water use and water management can lead to water use reductions, increased aquifer recharge rates, and surface and ground water quality improvements. To achieve this overarching goal, we will use the SWAT hydrological and water quality model to determine how changes in production practices and crops will affect water quality and flow,

and examine the kinds and levels of changes that will be necessary to achieve the state's water quality targets. Using survey data, we will examine the potential water use reductions and water quality improvements that would be undertaken by agricultural producers given various levels of market-based payments for ecosystem service provision. We will also determine the economic value of in-stream water use and water quality improvements by in-stream water users (beneficiaries) through the use of a survey to implement the travel cost and continuation valuation methods of non-market valuation. This will allow us to determine if collection of payments from users could partially or wholly offset necessary investments made by agricultural producers to achieve water quality and flow standards.

3. Pierre-Andre Jacinthe, PD, University of Indiana, Bloomington, IN 47405-7000

Assessing Threshold Benefits of Conservation Tillage During Drought Years: Implications For Nutrient-Use

Nutrient export from US Midwest croplands has created serious water quality challenges both in the region and beyond. Several climate models have predicted that the region's climate will be marked by frequent summer droughts interspaced by excessive rainfall. These hydro-climatic alterations could exacerbate nutrient export and water quality problems. In such a context, we argue that no-till (NT) farming provides an effective option to achieving sustainable water quality. Yet, NT adoption rate remains much below that of conventional tillage (CT) perhaps due to lack of awareness, among producers, of the economic and potential water quality benefits of the practice during severe droughts. Thus, our objectives in the proposed research are to: (1) assess the buffering effect of NT on crop yield, nutrient use efficiency, and leaching potential through simulation of drought in experimental plots under NT and CT, (2) determine the impact of drought severity on crop yield in fields under different tillage practices through satellite-based monitoring of root-zone soil moisture and spectral analysis of vegetation canopy, (3) conduct an analysis of the probability distribution of benefits associated with different tillage practices, and identify incentives and barriers to NT adoption, and (4) evaluate the general awareness, among producers, of the connection between climate variability, land management, crop yield and water quality, and determine how much climate information enters into their decision-making. Research will be conducted in the Eagle Creek watershed, IN. Archived satellite imagery (2000-2013) will be analyzed to develop drought severity distribution maps across the watershed in past years. Relationships will be drawn between drought severity and crop yield in fields under NT and CT and, from that analysis, a drought threshold for yield reduction will be derived for each tillage management (higher threshold expected under NT). Project results will inform policy decisions pertaining to land management under various scenarios of climate change. They are consistent with USDA-REE's goal to promote "water conservation efforts with a focus on socio-economic research and extension to increase adoption of appropriate practices and technologies to achieve increased water conservation at the farm/landscape/watershed scale."

4. David A. Keiser, PD, Iowa State University

4. David Keiser, PD, Iowa State University, Ames, Iowa 50011

The Value of Water Quantity versus Quality: Assessing the Tradeoffs between Agricultural Yields and Downstream Uses of Water Resources

Land use decisions and land management practices play a critical role in highly productive cropland. For example, decisions regarding agricultural drainage systems, tillage types, fertilizer use, and crop choices boost yields by responding to changes in economic, climatic, and other environmental conditions. However, due to the interconnectedness of hydrologic systems, these farm-level choices have important consequences for competing uses of water resources. In particular, important downstream uses such as drinking water, recreation, and aquatic life uses may be affected by changes in water quality due to these land management practices. In this project, we explore this important tradeoff between water quantity for agriculture and water quality for downstream uses. Our setting is the Upper Mississippi River basin and Ohio Tennessee River basin. These Midwestern watersheds encompass much of the economically valuable Corn Belt region of the U.S. However, due to nutrient and sediment loading from agriculture, many high value downstream uses currently experience significant strains. We propose to develop a spatially-explicit integrated hydrologic-economic model that estimates the economic value of water across uses. Through novel field, classroom, and online extension and education programs, we will engage students, stakeholders, and the general public on the importance of the economic value of water. Obtaining estimates of the value of water across uses is important to inform efficient and effective water policies and conservation practices.

5. Christopher D. Clark, PD, University of Tennessee, Knoxville, TN 37996

Using Hydro-Economic Modeling to Optimally Allocate Water in the Humid Southeastern U.S.

The long-term goal of this project is to assist agricultural producers, policymakers, and local communities throughout the Southeastern United States adapt to a new reality of water scarcity by more efficiently allocating water and adopting water-conserving practices and technologies. Efforts to achieve this goal are organized into five integrated project tasks: develop water budgets/water use inventories for five representative agricultural enterprises (irrigated crop, beef cattle, dairy, goat, and broiler production) by monitoring water use at three University of Tennessee Research & Education Centers (RECs); develop and disseminate a comprehensive state-wide education program to inform county Extension agents, agricultural producers and landowners about water use in agriculture and potential water-saving techniques for different agricultural enterprises using the water budgets and monitoring efforts at the RECs; generate temporally- and spatially-explicit estimates of water availability and scarcity across the study region (Mississippi River – Hatchie, Tennessee River and Cumberland River Basins) using the Variable Infiltration Capacity (VIC) water balance model under current

and projected economic and environmental conditions; develop and apply a partial equilibrium, economic model of the agricultural sector to generate spatially- and temporally-specific estimates of the economic values of water in different agricultural use categories linked to VIC forecasts; apply data from a regional input-output model to impute the economic value of water for non-agricultural sectors; and enhance youth and adult understanding of water availability, use, and scarcity in the study region and of the opportunities and need for water conservation by developing and disseminating a comprehensive state-wide education program.

6. Sandeep Kumar, PD, South Dakota state University, Brookings, SD 50776

Integrated Plan for Drought Preparedness and Mitigation, and Water Conservation at the Watershed Scale

The severe drought of 2012 in the USA caused substantial socio-economic and environmental damages where more than 1,400 counties in 33 states were designated as disaster areas. A strategy to prepare and respond to such drought is needed at the watershed scale. The main goals of the proposed study are to identify drought triggers, develop mitigation plans, investigate socioeconomic factors associated with new technology adoption, and educate different age group students about drought issues. Soil moisture sensors and tensiometers will be used to monitor daily soil moisture dynamics under different soils and management systems of the Skunk Creek Watershed of South Dakota where dominant agriculture is mostly rainfed. Existing weather data from weather stations located in the watershed will be used in regional climate models (RCMs) to predict future scenarios of daily precipitation and daily maximum and minimum air temperature. The projected weather data will then be used as an input to the watershed scale (Soil and Water Assessment Tool, SWAT) hydrologic model to determine spatial and temporal soil moisture dynamics. Simulation scenarios of management practices will enable to determine the best soil moisture conservation practices that can alleviate the drought impacts. Socio-economic aspects for adopting new technologies among the producers and other stakeholders in the watershed will be analyzed through surveys and interviews. Different age group students, stakeholders and policy makers will be educated on drought preparedness and mitigation. This project will provide resource managers and policy makers with new decision-making tools for conserving water resources in drought periods. Partially funded in FY2014.

7. Michael P. O'Neill, PD, University of Connecticut at Storrs, CT 06269

A Synthesis of the NIFA Water Portfolio (2000-2013)

Our project involves four objectives: 1) Determine lessons learned, critical findings, and outcomes of the NIFA Water Portfolio between 2000 and 2013; 2) Evaluate the effectiveness of national, regional, and watershed scale approaches to promote solutions and the effectiveness of integrated projects to move stakeholders closer to solutions; 3) Demonstrate synergies and failed synergies among projects in the NIFA portfolio and how these synergies improved leveraging; and 4) Identify water quality/quantity issues that NIFA should address and recommend the best approaches to address these. To achieve our objectives, we propose

seven activities: 1) Constructing a comprehensive matrix of projects drawn from the nine historic funding lines that have supported water research, education, and extension efforts; 2) Constructing a series of maps of the NIFA Water Portfolio; 3) Surveying investigators funded by the NIFA Water Portfolio to expand our knowledge of program outcomes, synergies, and leveraging; 4) Conducting focus groups in selected states; 5) Developing multiple case studies selected from the portfolio to explore circumstances that led to successful synergies (and failures) and to further determine critical findings and outcomes; 6) Identifying water science priorities for the NIFA Water Portfolio; and 7) Outreach and dissemination of findings. Upon completion of our project, NIFA will have a comprehensive synthesis of findings from their Water Portfolio (2000-2013). We will create an Atlas of investments based upon the NIFA portfolio and a template for future synthesis efforts on water (and non-water) portfolios. Finally, we will develop recommendations for future directions of water resources programs for NIFA.

D. Forest Products Competitive Program Awards (FRP)

1. Shaler, ST, PD, School of Forest Resources, University Of Maine, Orono, Maine 04469

Technical Assessment of Cross-Laminated Timber from Northeastern US Forests

Cross Laminated Timber (CLT) is a building product developed over 20 years ago in Europe which has seen increasing acceptance in the non-residential and multi-story building markets. CLT is used in floor, roof, and wall applications. Product advantages include rapid construction times and improved environmental profiles relative to the concrete systems with which it competes. Two manufacturing firms are now in existence in Canada. However, this product has seen only limited use in the United States and there are currently no production facilities. The ultimate goal of this research to provide information to address the technical feasibility of the creation of a facility to manufacture and market CLT and/or hybrid CLT systems to the northeastern US. The information to be determined and communicated with trade associations, architects, and manufacturing companies include the strength and stiffness of Norway spruce (a species growing in the Northeastern US not currently used for lumber), the manufacturability (including adhesion performance) of the panels, the short and long-term mechanical performance of CLT panels from this lumber and of a hybrid CLT panel comprised of lumber and a laminated strand lumber (LSL) product, and the energy performance of wall systems constructed of these hybrid CLT panels. The overarching goal of this proposal is to develop technical information to promote the establishment of a CLT production facility in the Northeastern United States. Critical activities and objectives supporting this goal that will be undertaken in this project are divided into four areas. Testing Norway spruce lumber for incorporation into SPFs grade - The outcome of the lumber testing program is to provide information and analysis sufficient for NeLMA to provide an official submission to the American Lumber Standards Committee (ALSC) Board of Review for the inclusion of Norway spruce into the SPFs species grouping. Manufacture of lumber and hybrid LSL/lumber CLT panels - The major objective is to manufacture pilot scale 3-ply CLT panels from Norway spruce and hybrid panels comprised of LSL faces and lumber core. Full-scale testing and evaluation of lumber and

hybrid CLT panels - The objective of the full scale testing is to validate the concept of hybrid CLT panels for a variety of grade and panel configurations. Hygrothermal response and thermal insulation value of hybrid CLT wall systems - The major objective of this series of experiments is to assess the thermal and moisture transport of LSL faced, lumber core and three ply panels made of Norway spruce. The collected data will allow thermal and moisture transport modeling of common wall systems.

2. Beyreuther, T.O., PD, Composite Materials & Engineering Center, Washington State University, Pullman, Washington 99164

ID Composite Next Generation CLT: Mass-Customization of Hybranel

The mass-customization of engineered wood building assemblies defines a new state-of-the-art in the design and construction of the built environment. Mass-customization utilizes exponential advancements in digital modeling, analysis, and fabrication to create optimized, unique building components with the same or increased efficiency and speed as mass-produced components. Mass-customization technologies are mature in automotive, aviation, and industrial product industries and are also advanced in the fabrication of some building construction materials such as steel and concrete. This forest products research project proposes hybrid cross-laminated timber (CLT) panel designs and processes to 1) leverage the existing strengths of mass-produced forest product components and 2) position CLT as a preferred mass-customized building assembly product in sync with emerging digital, parametric building design and digital fabrication methods. The core product will be an integrated design, fabrication, and assessment platform -- to be used by architecture and engineering design professionals -- for the next generation CLT system. This forest products research project proposes hybrid next-generation cross-laminated timber (CLT) panel designs and processes to 1) leverage the existing strengths of mass-produced forest product components and 2) position CLT as a preferred mass-customized building assembly product in sync with emerging digital, parametric building design and engineering methods.

3. John A. Nairn, Frederick A. Kamke, Lech Muszynski. Wood Science & Engineering Oregon State University, Corvallis, OR

Nonlinear Micro-Mechanics and Failure Analysis of Wood Adhesive Bonds

The goal of the research project is to create a model describing inelastic load transfer and failure mechanisms in adhesive-bonded wood systems that is capable of reflecting the morphological effects of adhesive penetration into cell lumens and the complex nature of the wood-adhesive interphase. The approach will be a coupling of three experimental methods with numerical modeling. First, X-ray computed tomography (XCT) will map the structures of wood-adhesive bonds and segment resin from wood cell walls. Second, the same specimens that are mapped by XCT will be loaded for micro-bond testing and use digital image correlation methods to map strain fields. Third, nano-indentation on wood cell walls and *in situ* resin will be performed to determine mechanical properties of cell wall and resin needed for the modeling.

The structure determined by XCT will be input to a material point method (MPM) numerical model that will explore the micro-mechanics and failure of wood-adhesive bonds. The MPM model will be validated by comparison to the experiments. Some specimens will be scanned by XCT in the loaded state and compared to modeling results. This project will extend previous work by the investigators to non-linear micro-mechanics, failure analysis, and nano-indentation experiments. The outputs will be a large database of XCT results for multiple species and resins, computer software for morphology-based modeling of wood bonds, and material models that can be used in finite element method (FEM) or other numerical packages to more realistically model the role of adhesive bonds on properties of wood structures and composites.

4. Muszynski, Lech; Sinha, Arijit, Gupta, Rakesh, Barbosa, Andre; Oregon State University

Hybrid CLT Panels for Sustainable Building Solutions

The goal of this project is to verify the hypothesis that underutilized domestic species (e.g. beetle killed pine BKP) and alternative adhesive systems can be successfully utilized in hybrid CLT products without compromising their critical engineering parameters. The supporting objectives are to: 1) determine effective adhesive system and bonding parameters for the hybrid CLT combinations; 2) develop an efficient in-house manufacturing capacity for full-sized CLT samples; 3) determine benchmark engineering parameters of hybrid CLT panels; 4) evaluate performance of typical CLT connectors with hybrid panels; 5) develop numerical models to predict the performance of hybrid CLT panels and their connection systems and create design guidelines based on the models. The investigators approach is to test the viability of specie/adhesive combinations in small-scale bond tests, and then compare the benchmark engineering characteristics of selected hybrid 3- and 5- layer CLT layups with mono-species structural grade full-size panels constructed per ANSI/APA PRG320- 2012 standard specifications used as reference. This research is important for the long term sustainability of the CLT industry in North America because utilization of low-grade timber in engineered products is expected to reduce the pressure on the structural lumber supply and provide a substantial outlet for BKP. The Pacific Northwest is uniquely positioned to become the hub for the US CLT industry and development of seismic resistant systems based on the CLT technology because of the proximity of populated seismic areas along the Pacific Coast and the access to the Pacific Rim markets. CLT manufacturing brings a potential to revive forest products oriented communities across the region.

5. Shaler, Stephen, Davids, William, Gardner, Douglas, J, Lopez-Anido, Roberto, Rice, Robert, Tajvidi, Mehdi, University of Main

Technical Assessment of Cross Laminated Timber from Northeastern US Forests

This research project provides technical feasibility information for a lumber and a hybrid cross laminated timber (CLT) for use in multi-story commercial and residential construction that will result in increased wood utilization, value, and manufacturing in rural locations. The initial geographic emphasis is the northeastern United States. The proposal specifically address evaluation of Norway Spruce for its use as a structural grade within the SPFs lumber classification, the evaluation of CLT panel properties attainable using SPFs lumber, assessment

of an innovative hybrid CLT using SPFs and Laminated Strand Lumber, and evaluation of the thermal and moisture behavior of CLT wall systems. Trade association (NeLMA, APA), governmental (FPL), and industrial (LP Building Products) partners are involved in the project and will be integral to material sampling, technical review, market relevance, and education/outreach. These project goals address the Forest Products Research Grant program goals under special area 4 - developing structural composites, and specifically incorporates the evaluation of Norway Spruce, wood/SCL hybrid panels, and durability of adhesive joints. In conjunction with NeLMA and the FPL, the project will provide design value recommendations. It will provide the first assessment of SPFs species grouping for CLT and the hybrid CLT will include LSL.

Appendix E. Small Business Innovation Research Funded Grants as Related to Environment and Natural Resources:

Phase I

8.1: Forests and Related Resources

1. Brian Skinn, PD, Faraday Technology, Inc., Clayton, OH

Electrocatalytic Oxidation of Lignin to High-Value Aromatics

This project will develop potential applications of FARADAYIC pulse-waveform electrochemical processing techniques for the oxidative conversion of lignin into high value products such as biofuels and other valuable chemicals.

2. Hiroshi Morihara, PD, HM3 Energy, Inc., Gresham, OR

Development of Reliable, Economical Briquetting of Torrefied Forest Residue without Binders to Produce Study, Water Resistant Briquettes”.

This project will develop densification procedures for using torrefied woody biomass to produce water resistant torrefied briquettes that can be stored outdoors and used in place of coal as fuel for commercial power plants.

3. Thomas Vaneck, PD, Physical Sciences Inc., Andover, MA

FlorianEye

This project will develop a high performance, low cost, small unmanned aerial system that will provide on-demand overhead aerial video surveillance to firefighters in order to enhance the safety and effectiveness of firefighters engaged in containing wildfires.

4. Agenor Mafra-Neto, PD, ISCA Technologies, Inc., Riverside, CA

Protecting Ponderosa Pine from Dendroctonus with VerbPlus Repel

This project will develop a long lasting product called VerbPlus Repel that contains the anti-aggregation pheromone verbenone and a blend of non-host angiosperm volatiles in an effort to disrupt orientation and host-finding behavior by western pine beetle and thereby protect ponderosa pine from mass attacks by this insect.

5. Kenneth Watts, PD, Thermal Framing LLC, Island Park, ID

Low Thermal Bridge Building Components Structural Research

This project will develop new wall framing components in order to reduce thermal bridging in exterior walls and thereby improve the energy efficiency of building systems.

6. Nehru Chevanan, PD, Altex Technologies Corporation, Sunnyvale, CA

Biomass Fuel Blocks Production System

This project will develop procedures for producing a high value feedstock from diverse forest residues through a process of biomass densification to produce compacted logs that can be used as fuel in place of coal.

7. Nathan Torbick, PD, Applied Geosolutions, Newmarket, NH

Operational SAR Forest Structure and Disturbance Metrics

This project will develop procedures for the use of synthetic aperture radar (SAR) to quantify forest structures and map forest disturbances in order to improve our understanding of forest health and sustainability.

8.4: Soil and Water Resources

1. Reactive Innovations LLC, \$100,000

Water treatment for agricultural contaminants for farms and small community disinfection. This is a mixed ozone and hydrogen peroxide system to treat pesticides, fertilizer, organics, *cryptosporidia* and *giardia* in rural water supplies.

2. Proton Energy Systems, \$100,000

Developing a high efficiency, low cost electrochemical ammonia production process that is a new nanotech method to produce ammonia fertilizer that can be cheaper than the current Haber Bosch process.

3. Aqua Vitae Monitoring LLC, \$36,500

This is a sensor technology to facilitate nutrient trading in rural water supplies.

4. Agren, \$99,979

This company will provide GIS and web-based soil loss modelling for government agencies by subscription. They currently have clients such as NRCS and FSA.

5. Micronic Technologies, \$99,970

A rapid blower/evaporator system cleans rural drinking water of contaminants, heavy metals, bacteria, and fracking water salts.

6. MetaMateria Technologies LLC, \$100,000

These nano-ceramic filters at the end of tile drains will remove nutrients and pharmaceuticals with high volume/low pressure filters.

7. NBD Nanotech, \$100,000

This super hydrophobic coating on netting will capture moisture from fog to harvest water in arid coastal regions.

8. Southwest Science Inc., \$100,000

This real time air sampler will measure hydrogen sulfide and methane from agricultural operations such as livestock.

Phase II

8.1: Forests and Related Resources

1. Igor Novosselov, PD, Enertechnix Inc., Maple Valley, WA

Advanced Control System for Biomass Combustion

This project is developing an advanced combustion control system consisting of an array of low cost sensors that feed a real-time analysis module that in turn directs both the primary and secondary air flow control in order to continuously minimize emissions.

2. Roald Gundersen, PD, Whole Trees, LLC, Madison, WI

Forest-to-Factory: Round Timber Supply Chain Tools and Techniques

This project is developing new markets for non-uniform round timbers by applying new digital technologies to locate, scan and screen trees in the forest, and then inventory, engineer, and precisely manufacture them into structural assemblies.

8.4: Soil and Water Resources

1. Kansas Environmental Management Associates LLC, \$449,800

This project will remove excess phosphorus from ethanol distilled grain to produce a profitable fertilizer and reduce excess nutrients in livestock feed.

2. Micronic Technologies, \$450,000

Rural community well water treatment for nitrates and other pollutants with high volume blower/evaporator system.

3. Nutrient Recovery and Upcycling LLC, \$450,000

Phosphorus fertilizer recovery from anaerobic acid digesters in sewage treatment plants.

4. Precision Combustion Inc., \$449,898

Compact, efficient soil steam sterilization system to replace methyl bromide.

REPORT PREPARED BY JIM DOBROWOLSKI WITH HELP FROM DES STAFF