**Purdue Extension**
**2018 Annual Accomplishment Report to USDA NIFA**
**Impact Statements by Planned Program**

The Purdue Extension and Research outcomes and impact statements are organized into these seven Planned Programs:

- Childhood Obesity
- Climate Change
- Food Safety
- Global Food Security and Hunger
- Human, Family, and Community, Health and Well-being
- Natural Resources and the Environment
- Sustainable Energy

Outcomes provide the metrics that our Educators and Specialists report across research and Extension program efforts. The impact statements shared highlight a program or project addressing the outcomes and provide narrative on the issue, what has been done, and the results. There are impact statements for research projects, for Extension programs, and for integrated research and Extension activities.

===================================

# *Sustainable Energy*

Title
Biocatalytic Processing for Renewable Resource Utilization

Research
Nathan Mosier, Agricultural and Biological Engineering

Outcome
6 - SE 4.1 - # New technologies developed

Issue
Federal mandates for the production and use of advanced biofuels has increased the importance of developing technologies to reduce costs and improve efficiencies for cellulose-to-fuel production processes. Technologies that reduce the costs associated with generating fermentable sugars from plant biomass, (e.g., pretreatment and hydrolysis), can have immediate and substantial impacts. Costs associated with cellulose hydrolyzing enzymes are an order of magnitude more expensive than starch-degrading enzymes.

What has been done
The project goal is to develop fundamental knowledge of molecular and engineering processes required for sustainable conversion of renewable resources to transportation fuels and value-added products reducing the carbon footprint of agriculture and industry. The research is identifying lower cost technologies and enhancing the economics of transforming renewable resources to value-added and low carbon footprint molecules. A second objective relates to the application of bio-separation and enzyme technologies, developed for conversion of cellulose to biofuels to the rapid and cost-effective detection of food pathogens. Researchers are studying the impact of plant cell wall structure on its catalytic or bio-catalytic processing into molecules that serve as precursors or end products for use as transportation fuels; carrying out fundamental studies on catalytic mechanisms by which transformations may occur using either enzyme, chemical or microbial (fermentative) catalysts, and developing biochemical processes for effective transformation of plant cell tissues into identifiable alcohol, aldehyde, and aromatic molecules.

Results

For cellulose conversion, liquefaction of biomass that combines modeling of particulate material into pellets and pellets into liquefied biomass material has been initiated. A combination of fluid, solids and particles systems computational models, together with fundamental measurements of innate properties of corn stover particles are being used to define an envelope of processing conditions that lead to pumpable slurries of biomass materials at concentrations between 20% and 30%. For catalytic process, further research has proven beneficial effects of using non- catalytic proteins to block adsorption of enzymes onto lignin, thereby reducing the amount of cellulases by a factor of 5x to 10x required to carry out hydrolysis of cellulose in liquid hot water pretreated corn stover, hardwood and sugarcane bagasse. For biochemical processes, researchers developed a method to recover lactic acid from food waste at optimized conditions and accounted for understudied factors that influence yield (RedCorn and Engelberth 2018). Researchers quantified glycogen production potential from waste activated sludge employing enhanced biophosphorus removal techniques (RedCorn and Engelberth, 2018). In terms of food processing, researchers compared potential avenues for upgrading food waste and determined that higher value potential could be achieved from recovering a niche product rather than processing the waste via anaerobic digestion (RedCorn, Fatemi, and Engelberth, 2018). Researchers quantified the volume of lutein and zeaxanthin in distiller's dried grains with solubles (DDGS) and determined there was a non-trivial quantity and that further study is required to determine a cost-effective recovery method (Li and Engelberth, 2018). These research findings can help build understanding for more cost-effective technologies for biofuel production.

Title
Global Change and the Challenges of Sustainably Feeding a Growing Planet

Research
Tom Hertel, Agricultural Economics

Outcome
74 - SE 5.6 - # Policy makers increased knowledge of decision models

Issue
Since the 2007/2008 commodity crisis, there has been a resurgence of interest in sustainability of the world food system and its contributions to feeding the population and ensuring environmental sustainability of the planet. The number of people which the world must feed is expected to increase by another 2 billion by 2050 (Bloom 2011). When coupled with significant nutritional improvements for the 2.1 billion people currently living on less than $2/day (World Bank 2008, p.1), this translates into a very substantial rise in the demand for agricultural production. Food and Agriculture Organization of the United Nations (FAO) estimates increased demand at 70% of current production, with a figure nearer 100% in developing countries (Bruinsma 2009, p.2). Over the past century, global agriculture has managed to offer a growing population an improved diet, primarily by increasing productivity on existing cropland. In addition, agriculture and forestry are increasingly envisioned as key sectors for climate change mitigation policy. When combined, farming and land use change - much of it induced by agriculture - currently account for about one-third of global greenhouse gas emissions (Baumert, Herzog, and Pershing 2005). If incorporated into global climate policy, these sectors could contribute up to half of all mitigation in the near term, at modest carbon prices (Golub et al. 2009). Any serious attempt to curtail these emissions will involve changes in the way farming is conducted and place limits on expansion of farming - particularly in the tropics, where most of the agricultural land conversion has come at the expense of forests. Limiting the conversion of forests to agricultural lands is critical to preserving biodiversity on the planet (Green et al. 2005). These factors will restrict the potential for agricultural expansion with growing global demands. Finally, agriculture and forestry are likely to be the economic sectors whose productivity is most sharply affected by climate change (Lobell, Schlenker, and Costa-Roberts 2011; Schlenker and Roberts 2009). This will shift the pattern of global comparative advantage in agriculture (Reilly et al. 2007) and may reduce productivity of farming in precisely those regions of the world where poverty and malnutrition are most prevalent (Hertel, Burke, and Lobell, 2010), while increasing yield variability and vulnerability of the poor (Ahmed, Diffenbaugh, and Hertel, 2009).

What has been done
The broad objective of this project is to improve our understanding of the interplay between population and income growth, biofuels policy and production, international trade, climate impacts and policy in determining future food security, land use change and greenhouse gas (GHG) emissions at global and regional scales. Land-based GHG emissions

account for about one-third of total GHG emissions and could offer up to 50% of efficient abatement potential at modest carbon prices. Yet current predictions of land use change and GHG emissions over the coming century are highly uncertain and often ignore economic factors altogether. Improving predictions and developing coherent policy recommendations which account for dynamic interplay between these forces is a high priority. To improve on the current state of knowledge and policies, the project has these objectives: 1) Understand and quantify the drivers of global changes in land use and GHG emissions, project such changes forward to 2050 or 2100, and formulate optimal policy responses to such changes. 2) Evaluate impact of uncertainty in climate impacts, change mitigation policies and energy prices on both optimal and observed land use change at global scale. 3) Assess impact of future water shortages on global food production, trade and land use. 4) Assess impacts of these global changes on world food prices, food security, livelihoods and poverty in developing countries.

Results

Researchers assessed the need for public investments in research and development (R&D) over the 21st century in light of the very long lag between such investments and U.S. agricultural productivity outcomes, and considerable uncertainty in future population, income and bioenergy growth, and climate impact. R&D has been the major driver of U.S. farm productivity growth since WWII, yet spending has recently leveled off and has even been declining. Failing to invest today in improvements of agricultural productivity cannot be simply corrected a few decades later if the world finds itself short of food. Researchers computed the optimal path of agricultural R&D spending over the 21st century for each Shared Socioeconomic Pathway, along with valuation of regrets associated with investment decision-making. Regret is minimized to find a robust optimal R&D pathway that factors in key uncertainties and the lag in productivity response to R&D. Results indicate that the whole of impact by uncertainty on R&D is greater than the sum of its individual parts. Uncertainty in future population was the dominant impact on optimal R&D expenditure path. The robust solution suggests that the optimal R&D spending strategy is very close to the one that will increase agricultural productivity fast enough to feed the world under the most populous scenario. It also suggests that society should accelerate R&D spending up to mid-century, thereafter moderating this growth rate. These computation results may help in decision-making to support R&D for agriculture productivity to feed the population of the planet.