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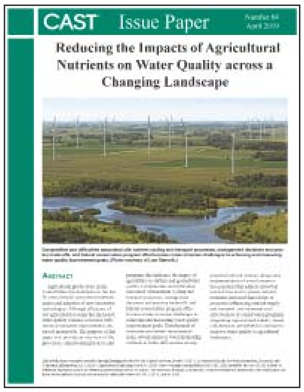
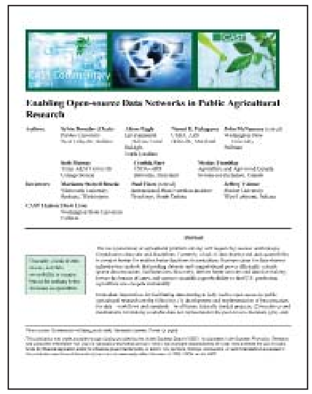
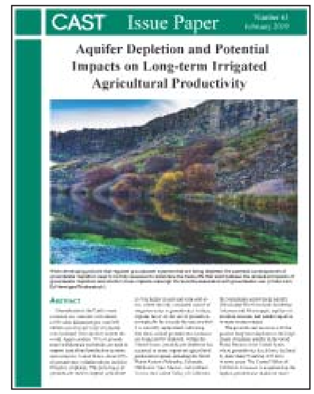


Reducing the Impacts of Agricultural Nutrients on Water Quality across a Changing Landscape



Enabling Open-source Data Networks in Public Agricultural Research



Aquifer Depletion and Potential Impacts on Long-term Irrigated Agricultural Productivity

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- *Ground and Aerial Robots for Agricultural Production: Opportunities and Challenges (Fall 2019)*

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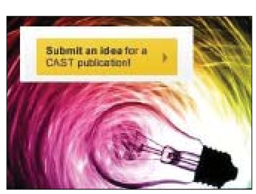

The Borlaug CAST Communication Award recognizes professionals actively working in the agricultural, environmental, or food sectors who are promoting agricultural science in the public policy arena. The 2018 award goes to **Marty Matlock**, an internationally recognized expert in agricultural sustainability metrics and assessment.

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Ag quick CAST

CAST Issue Paper 64
April 2019
Material excerpted from original CAST document

Reducing the Impacts of Agricultural Nutrients on Water Quality across a Changing Landscape

Supplying external inputs of nutrients such as nitrogen (N) and phosphorus (P) to cropland in order to maximize crop production was first recognized nearly 200 years ago, and today 40 to 60% of [U.S.] crop yield is attributable to fertilizer.

- Although many sources contribute nutrients to water bodies, agriculture remains a significant source in many areas of the United States.
- U.S. agriculture faces an unprecedented challenge—support growing domestic and global agricultural product demands while minimizing environmental impacts on local and regional water resources.

Nutrient loss from agricultural fields and watersheds is determined by the complex interaction among numerous physical, chemical, and biological variables.

- Fertilizers and manures have the potential to elevate nutrient concentrations in surface runoff and subsurface leachate, particularly if applied beyond crop need.
- Research across diverse agricultural landscapes in the United States has shown that hydrological processes are an important component driving nutrient loss.

Nutrient management not only has direct implications for crop productivity, but it can also strongly influence nutrient losses to groundwater and surface water bodies.

- The right source of nutrient is dependent on the nutrient content, its solubility, and whether it is regionally available.
- Nutrient application rates are determined differently for P and N.
- Nutrient placement can have significant implications for both crop uptake and nutrient loss.
- The right timing of nutrient application aims to ensure there is adequate nutrient supply during peak crop uptake and critical crop growth stages.

Conservation practices can be used in combination with nutrient management to decrease nutrient loss from cropped fields.

- Vegetated filter strips, buffers, or riparian zones are often implemented between the edge of an agricultural field and a stream or drainage ditch.
- Integrating single or multispecies cover crops with the primary commodity crop system will decrease the amount of time that fields are left with bare soil.
- Sediment detention basins capture agricultural surface and subsurface drainage water and allow sediment and particulate nutrients to settle out prior to the water entering a stream or ditch.
- Constructed wetlands have the potential to remove nutrients from agricultural drainage water.
- For fields with subsurface tile drainage, drainage water management or controlled drainage can be used to artificially adjust the outlet elevation of the drainage network to a specified depth by restricting flow.
- Both bioreactors and P removal structures have been implemented using various designs and can be installed separately or in series.
- Two-stage ditch systems incorporate benches that function as flood plains in an attempt to restore or create natural alluvial channel processes.

The combined demands of increased agricultural production with reduced environmental impact require management strategies that can be sustained over the long term.

- Current knowledge of N and P rates is imprecise.
- Legacy nutrients may mask water quality impacts of current conservation efforts.
- Most implemented conservation practices do not address dissolved nutrients.
- Few conservation practices provide in-stream nutrient removal.
- Nutrient reductions for both nutrient management practices and conservation practices are field specific.
- Conservation program success requires collaboration and cost-effective implementation.

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Ag quick CAST
CAST Commentary QTA2019-1
March 2019
Material excerpted from original CAST document

Enabling Open-source Data Networks in Public Agricultural Research

The next generation of agricultural problem solving will require big science and linkages forged across data sets and disciplines.

- Agriculture's pathway forward requires dedicated partnering among domain researchers, data scientists, science administrators and agencies, professional societies, and private publishing entities.
- Teams must bridge expertise gaps through meaningful collaborations between agricultural researchers and data scientists.
- Initiatives to leverage assets should focus on surfacing grey-dark data not represented by peer-review publication.
- For research data to achieve and maintain public value, it must connect feedbacks to ensure data are useful and useable for informing the end-user "apps" designed to enhance and secure our current food supply and address environmental and social challenges.

Research has created the most efficient food production system in history through accrual of massive amounts of data, information, and knowledge.

- With much research data remaining unpublished, only partially available, or incompletely described, policy decisions and program design may lean disproportionately on expert opinion and partial information.
- For agriculture, the scope of opportunities and challenges linked to data is hard to overstate.
- Free and open access to information generated by federal funding is clearly in the spirit of the original legislation creating the USDA and the land-grant university system to develop and apply scientific knowledge in food production for the betterment of the U.S. population.

Although agricultural research has been slow in developing e-infrastructure and mechanisms that promote efficiencies and transparency via open data, examples from other domains demonstrate that open data can catalyze new discoveries, decisions, and economic growth.

- Reports in the agricultural literature have repeatedly highlighted the potential for such infrastructure to improve the quality of the primary agricultural literature and its use in evidence-based decision making.
- Numerous, large, data-sharing efforts initially developed for other, broader purposes are already bringing significant ancillary benefits to agricultural research.
- Moving agriculture from its present culture of short data life cycles and limited sharing to one valuing open data and data reuse requires development and implementation of best practices that ensure readability over time and between disciplines.

Simultaneous pursuit of four strategies will facilitate agriculture's pathway forward into data-driven research:

- Bridging gaps with novel teams and data sciences
- Institutional facilitation of team science and data sharing
- Leveraging assets and surfacing grey/dark data
- Connecting feedbacks to ensure data are useful and usable

Physical and cyber infrastructure require a business case for making open access data and data tools viable to start and sustain over the long term.

- Competitive grants programs could be extremely useful to build tools and apps but would not be efficient mechanisms for long-term data storage and curation.
- As agriculture considers pathways forward for data, careful examination of the various financial models currently under active consideration by other domains should be undertaken.
- Even with stronger requirements from funders for data preparation, some activities such as anonymization remain beyond the scope of the funded research.

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Ag quick CAST

CAST Issue Paper 63
February 2019
Material excerpted from original CAST document

Aquifer Depletion and Potential Impacts on Long-term Irrigated Agricultural Productivity

Groundwater is the Earth's most extracted raw material.

- Approximately 70% of groundwater withdrawals are used for irrigated agriculture.
- Consequences of the long-term depletion of groundwater resources include the direct impacts of depleting the resource and global impacts of groundwater being released to the atmosphere and oceans once it is brought above ground.

Groundwater use has grown significantly across the United States over the last century, especially to supply irrigated agriculture.

- Technology began to be deployed extensively across the United States in the 1950s, which coincided with rural electrification across the nation that facilitated use of submersible pumps.
- A second factor increasing groundwater use has been long-term regional droughts, especially in regions with large agricultural sectors.
- Additional factors include over-allocation of surface water and local availability of groundwater as a "point-of-use" resource not requiring expensive distribution infrastructure.

Several large aquifer systems in the United States are experiencing substantial problems from the depletion of groundwater.

- The U.S. aquifer system with the greatest long-term groundwater storage depletion is the Ogallala aquifer in the Great Plains region of the United States.
- Two large aquifer systems in the Pacific Northwest region of the United States, the Columbia Plateau aquifer and the Snake River Plain aquifer, have had a net accretion of groundwater levels as compared to predevelopment conditions.

Although a large direct consequence of depleting groundwater resources is the loss of water supply, many other consequences of depletion also must be considered:

- Reduced flow to surface water systems and ecosystems
- Loss of productivity of groundwater wells
- Subsidence of land and ground failures
- Degradation of groundwater quality

There is a growing recognition of the consequences of groundwater depletion. This has led to several approaches to mitigate or reverse groundwater depletion.

- The most direct approach to decreasing the depletion of groundwater is to simply extract less groundwater from aquifers.
- Another direct approach to arresting groundwater depletion is to enhance groundwater replenishment using alternative water sources.
- Another method to decrease groundwater depletion is through changes to crop selection and agricultural practices.
- Since each state has primacy over its water resources, a wide range of policy and institutional approaches has developed to address groundwater depletion across the United States.

Use of a groundwater resource requires that the groundwater table must be drawn down to some degree before it can be used in a beneficial manner.

- Lowering of an aquifer's groundwater table in small amounts is unavoidable and not in and of itself a negative condition.
- The potential consequences of groundwater depletion need to be fully assessed to determine the trade-offs that exist between the undesired impacts of groundwater depletion and whether these impacts outweigh the benefits associated with groundwater use.

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CAST Issue Paper 62
September 2018
Material excerpted from original CAST document

Food Loss and Waste—A paper in the series on The Need for Agricultural Innovation to Sustainably Feed the World by 2050

Despite tremendous progress, food insecurity, hunger, and malnutrition are still widespread.

- Natural resources fundamental to agricultural production are limited.
- Agriculture has become a dominant force for the decline in water quality worldwide.

No single comprehensive estimate of food loss and waste (FLW) exists in the United States.

- The first major U.S. data source is the U.S. Department of Agriculture's Economic Research Service's Loss-Adjusted Food Availability data series.
- The second major source of data is from the U.S. Environmental Protection Agency, which provides estimates of the amounts of food waste entering municipal solid waste facilities.
- The third source of data originates from a report by the Natural Resource Defense Council.
- The fourth estimate is from ReFED, a multistakeholder nonprofit organization with the goal of providing a roadmap to decrease U.S. food waste by 20%.

Why food loss and waste (FLW) occurs.

- Estimated on-farm FLW totals 9.1 million tonnes, the vast majority of which ends up being returned to the soil.
- The food industry, including manufacturers and consumer-facing businesses, generates 23.6 million tonnes of food waste.
- Consumer level FLW is the single largest component of all FLW in the U.S. food chain.

The road to a 50% reduction is long and time is short.

- A great deal of effort has gone into promoting food waste composting.
- For the nation to work toward the 50% reduction goal, it is important to quantitatively assess the effectiveness of the current programs and measures.

A potential game changer in the realm of food waste reduction, recovery, and recycling is to convert food waste generated at the consumption state into animal feed.

- The technological innovation needed for a game changer is one that can effectively dehydrate, sanitize, and homogenize food waste materials.
- Other practical issues to address include what animal species would be most suitable or would benefit the most from feeding (treated) consumer food waste.
- Such technological innovation, coupled with research addressing the production and economic essentials, could have the potential for a transformative change of the current food waste management paradigm.

Changing consumer behavior from wasteful to sensible use of food is the best option for the most desirable outcome.

- Humans have always wasted food, but the scale of the problem today is unprecedented in history.
- The decisions and actions consumers make and take are not necessarily rational nor straightforward but subject to the influence of many internal and external factors.
- The ability to meet the challenges of food waste reduction, resource conservation, and environmental sustainability hinges to a large extent on individual consumers' willingness to alter their habits and behavior and cut down their foodprint.
- Substantially decreasing food waste is attainable.

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Ag quick CAST
CAST Issue Paper 61
July 2018
Material excerpted from original CAST document

Impact of Free-range Poultry Production Systems on Animal Health, Human Health, Productivity, Environment, Food Safety, and Animal Welfare Issues

The domestication of animals for food production has played an important role in the development of agriculture as a whole.

- In the last few decades, the number of eggs a hen can lay each year has doubled and the amount of feed required to produce these eggs has been cut in half.
- In 1923, [meat] chickens were raised to 16 weeks of age and only weighed 1 kilogram (kg) (2.2 pounds [lb]). The feed efficiency of weight of feed to weight of body weight gain was 4.7. By 2001, chickens were raised to 6 weeks of age and had a live weight of 2.6 kg (5.73 lb). Feed efficiency was improved to 1.63.
- Despite the ever-increasing separation between farming and the general public, today's consumers are increasingly interested in where their food comes from and how the food is produced.
- As a result of consumers' changing perception of animal production systems, there has been an increased interest in free-range poultry production.

Although many perceive free-range poultry production systems to be more animal welfare friendly, the research comparing the different production systems is inconclusive and often contradictory.

- Comparisons of poultry production systems must examine the effects of flock size in addition to the housing system used.
- A computer model was developed to assess the welfare of laying hens housed in different production systems.
- Although there have been several studies comparing the welfare status of laying hens in different management systems, there are only a few looking at meat poultry.

The popular literature addressing the effect of free-range production systems on food quality is contradictory and can be confusing to consumers.

- What the hens eat is more important than whether or not they go outside.
- It does appear that the nutrient content of poultry meat and eggs can be enhanced with access to pastures, with the effect depending on the type and quality of the pasture provided.

Food safety is another factor in the production system debate.

- The main factors that put poultry flocks at risk for microbiological contamination include the season of the year, the size and strain of the flock, housing system, control of rodents, cleaning and sanitation, and mixing of hen ages.
- Regardless of the research conclusions concerning relative food safety of chickens, consumers should not assume that all free-range chickens are free of *Salmonella* and *Campylobactor*.
- Proper handling of poultry meat from any production system is essential and should not be overlooked based on the production system used.

Optimal health management is key to successful poultry production.

- Studies have shown increased mortality in free-range production systems compared to conventional cages.
- There are several reports indicating that the incidence of helminth infections is higher when poultry have outdoor access as compared to the incidence of such infections when raised in conventional housing.
- There is concern that free-range poultry may serve as reservoirs of disease exposure to conventional production systems.
- Although free-range poultry may be more vulnerable to certain diseases, there is no indication that the presence of free-range poultry poses a risk to conventional poultry.

The main aim of sustainable animal production is to produce a high-value animal protein in a sustainable manner.

- The environmental impact of poultry production depends on several factors, and waste disposal is a primary concern.
- Animals, feed, manure, and housing accessories contribute to potential sources of the environmental footprint.
- Mortality rates tend to be higher in free-range production systems compared to conventional indoor systems. The general effect of increased cumulative mortality was to increase all environmental impacts, including greenhouse gas emissions, eutrophication potential, acidification potential, pesticide use, abiotic resource, and land occupation.

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Ag quick CAST
CAST Issue Paper 60
July 2018
Material excerpted from original CAST document

Genome Editing in Agriculture: Methods, Applications, and Governance

A paper in the series on The Need for Agricultural Innovation to Sustainably Feed the World by 2050

Genome editing is the process of making precise, targeted sequence changes in the deoxyribonucleic acid (DNA) of living cells.

- Genome editing, as it is most frequently practiced, uses reagents that specifically recognize and precisely cleave DNA targets within the genomes of living cells.
- It is also possible to create targeted modifications using short pieces of DNA (oligonucleotides).
- Recently, an approach to genome editing that allows specific mutations of individual DNA bases without requiring a double strand break has been developed.

Genome editing has the potential to have a large, positive impact on plant agriculture.

- One reason is the efficiency of the technology.
- A second reason is that in contrast to random mutagenesis, it causes relatively few or no mutations at unintended sites in the genome.
- Finally, genome editing allows knowledge-based alterations to a plant genome.

There are numerous recent reviews on genome editing in livestock.

- Much effort has been devoted to improving production traits.
- A number of applications target improved livestock health.
- There is increasing effort to use genome editing technology to improve livestock as bioreactors.
- Finally, as in plants, genome editing has been pursued to develop strategies for biocontainment of animals, with a focus on transgenic fish.

The new technology has accelerated the development of improved crop varieties and livestock with commercial potential, making clarity in how they should be governed paramount.

- Issues that will affect governance of this powerful technology as it relates to plant and animal improvement include how genome editing compares to other methods of genetic manipulation, environmental and animal welfare impacts of specific applications, values of producers and consumers, and economic impacts, among others.
- No method of genetic modification, including conventional plant or animal breeding, is without the possibility of unintended effects.
- Genome editing is likely to be subject to the same underlying factors of information processing and risk perception by individuals that have been found across multiple other emerging technologies.
- Genome editing may help smaller companies and public sector organizations innovate in the development of improved crops and livestock, particularly in specialty crops or livestock species for which there are not large commodity markets.

The power of genome editing suggests that, if conducive social and regulatory conditions are in place, it can substantially increase the positive impacts of plant and animal breeding on human welfare and sustainability.

- A distinction between product- versus process-based regulatory systems is that the latter must be revisited with every innovation in process; product-based regulatory systems are therefore more likely to be stable.
- U.S. Secretary of Agriculture Sonny Perdue issued a definitive statement that the USDA "does not regulate or have plans to regulate plants that could otherwise have been developed through traditional breeding techniques as long as they are not plant pests or developed using plant pests."
- An advocate general in the European Court of Justice issued an opinion that suggests that some genome-edited organisms need not be regulated in the same way as conventional GM organisms.
- Successful deployment of genome editing for crop and livestock improvement will benefit from science-informed, value-attentive regulation that promotes both innovation and transparency.

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Ag quick CAST

CAST Special Publication 32
May 2018
Material excerpted from original CAST document

Omega-3 Fatty Acids: Health Benefits and Dietary Recommendations

Omega-3 fatty acids have received a great amount of research attention in the past decade as a nutritional food supplement because of their many demonstrated and putative benefits for human health.

- The content of omega-3 fatty acids in meats, milk, and plant-derived foods can be increased by selective breeding and manufacturing procedures.
- A plethora of clinical and epidemiological evidence relates to the beneficial effects of omega-3 fatty acids, as in fatty fish, and is especially strong in neurocognitive disease.
- Growing evidence is emerging that omega-3 fatty acids have immunomodulatory effects and thus may be useful in treating inflammatory conditions such as rheumatoid arthritis, Crohn’s disease, ulcerative colitis, psoriasis, asthma, lupus, and cystic fibrosis.
- Because of the great interest in health benefits of omega-3 fatty acids, agricultural and manufacturing practices are becoming available to increase concentrations of these nutrients in common animal- and plant-derived foods.

Omega-3 fatty acids are among the most studied compounds in biomedicine, from molecular biology and human genetics to food production.

- Omega-3 fatty acids are relevant to humans throughout the life cycle.
- Humans are sensitive to omega-3 fatty acid deficiency starting in fetal life.
- Scores of studies show that animals deprived of omega-3 fatty acids through gestation and lactation exhibit abnormalities in neurotransmitter levels, catecholamines, and signaling compounds compared to animals with a supply of omega-3 fatty acids.

Evidence for a role of long-chain omega-3 fatty acids in human health originates in preclinical and clinical studies showing composition of tissue or specific functions such as clotting or inflammatory function.

- The protective effect of omega-3 fatty acids toward cardiovascular disease development most likely relates to beneficial modification of a broad range of risk factors.
- Anti-inflammatory actions of omega-3 fatty acids may be important in preventing or slowing some steps in tumor initiation, particularly in some cancers such as colorectal cancer.
- Of the fatty acids studied, omega-3 fatty acids seem to possess the most potent effects on the immune system and its inflammatory component.
- Omega-3 fatty acids have important roles in the brain beyond infancy and indeed may be important for brain function throughout the life course.

The most important change in foods that will enhance omega-3 status is reduction in linoleic acid in foods and replacement with oleic acid, as is done with most high-oleic oils.

- Enhancing the omega-3 fatty acid content of several common commodity oils has become a research focus that could be applicable for human and livestock applications.
- Increasing the omega-3 fatty acid content of some animal products can be achieved by the addition of high-alpha-linolenic acid oil seeds to the diet.
- Currently, the most success of enhancing omega-3 fatty acid via dietary means has been achieved in poultry meat and eggs.
- The success of enhancing omega-3 fatty acid content via dietary means in livestock has been less successful than in poultry.
- With an increased demand for omega-3 fatty acids, wild-caught marine-based sources are considered unsustainable; therefore, efficient alternatives that could provide omega-3 fatty acids have become an industry priority.

The area of labeling and claims related to omega-3 fatty acids is arguably even more complex than the potential health benefits and the science underlying those benefits.

- Nutrient content claims are label claims that, directly or by implication, characterize the level of a nutrient in a food.
- A dietary supplement using a structure/function claim (one that describes the role of a nutrient or dietary ingredient in affecting normal structure or function in humans) must also carry the disclaimer that the Food and Drug Administration has not evaluated the claim, and that the product is not intended to diagnose, treat, cure, or prevent any disease.
- All labels for meat and poultry products that include a statement about the level of omega-3 fatty acids must be provided to the Food Safety and Inspection Service for approval before use.

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Ag quick CAST
CAST Task Force Report 143
April 2018
Material excerpted from original CAST document

Scientific, Ethical, and Economic Aspects of Farm Animal Welfare

Large-scale, intensive systems of agricultural animal production predominate animal agriculture in the United States.

- The United States has historically had minimal agricultural animal welfare legislation beyond the 28 Hour Law and the Humane Methods of Slaughter Act, which, respectively, mandate humane conditions for transportation of livestock entering the food chain and rendering them insensible prior to killing.
- There is an urgent need to evaluate the implications of alternative housing and production practices on the welfare of agricultural animals.
- It is imperative to understand which systems and practices may optimize economic efficiencies in conjunction with ensuring positive animal welfare outcomes and public support of animal agriculture.

Animal welfare is multifaceted and involves consideration not only of animals' biological and psychological capacity to adjust to their living conditions, but also of human factors such as customs, norms, and values.

- Animal welfare science is now a well-developed field of inquiry, and there is abundant multidisciplinary literature on various aspects of behavior, health, physiology, nutrition, neurobiology, and genetics relevant to animal welfare.
- The ability to apply scientific findings about farm animal welfare may be constrained when there are conflicting values and norms related to animal use and treatment among the various stakeholders.

The economics of animal welfare remains a relatively nascent area of academic research.

- Additional research on the economics of animal welfare is needed to understand the extent to which rising prices resulting from the higher costs of new animal production systems will curb consumer purchases of livestock products.
- The precise reason for the divergence in shopping and voting outcomes is not well understood.
- Improved understanding of consumer heterogeneity may help recognize distributional effects of policies as well as niche marketing opportunities.

In the United States, there are few laws that directly address on-farm practices related to animal care and welfare.

- Production management practices and housing systems for farm animals have been a frequent target of legislative initiatives.
- It can be argued that the lack of a unified transparent process for establishing standards of care for commercial animal agriculture has precipitated the irregular patchwork of state-by-state regulations and competitive voluntary regulatory programs under which the industry currently operates.

Despite being a relatively new field, there is now a significant body of animal welfare research.

- Continuous confinement housing that results in ongoing behavioral restriction of animals has become one of the more controversial aspects of livestock production in the United States.
- Painful practices are routinely performed on farm animals for a variety of reasons, including to prevent them from injuring one another or human caretakers and for production and food quality purposes such as preventing boar taint in pork or increasing marbling of beef.

In the past 60 years, intensive selection for increased meat, egg, milk, and wool production has resulted in large increases in productivity and efficiency, which will likely lead to an increased number of side effects, including animal welfare issues.

- Selection for increased robustness can include selection for traits associated with fitness, including survival rates, leg structural soundness, and longevity.
- A second alternative is selection to change the behavior of animals to be better adapted to the production system.
- Group selection or individual selection for performance (e.g., egg production or growth) in family groups automatically includes an animal's social effects on the performance of others in the groups, including survival.

Adequately addressing the challenges posed by increasing public concern about animal welfare requires new knowledge and approaches, greater inclusiveness, and improved communication between scientists, policymakers, and the public.

- Increase capacity for scientific research on animal welfare in the United States.
- Increase focus on transdisciplinary aspects of animal welfare research.
- Develop coordinated mechanisms for policy setting.
- Effective communication about animal welfare is necessary to advance public understanding and improve application of the related science.

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Ag quick CAST
CAST Issue Paper 59
March 2018
Material excerpted from original CAST document

Regulatory Barriers to the Development of Innovative Agricultural Biotechnology by Small Businesses and Universities

Since the early 1980s, American taxpayers have invested heavily in public, university, and small business developers of crops and foods improved using biotechnology.

- The return on this investment is disappointingly thin.
- In theory, scientifically sound regulations serve the public good by assuring a reasonable degree of product safety while not unduly stifling innovation.
- This report analyzes the current U.S. regulatory system for genetically engineered (GE) crops, compares it with those of major trading partners, and considers various aspects of agricultural biotechnology regulation.

Much of the enabling technology for agricultural biotechnology was developed in academic or other public institutions.

- Many of the earliest field trials with GE plants were conducted by the public sector and academics at various universities, and some of the earliest commercialized crops receiving regulatory approval were from academia.
- Despite foundational contributions requiring considerable public resource commitments for GE crop innovation and development, the academic institutions and small private entities have been almost entirely excluded from the agricultural biotechnology market.

There is ample evidence that GE in plant breeding is of benefit to farmers, to consumers, and to the environment.

- When the USDA surveyed farmers, asking why they choose GE varieties, farmers said that GE crop benefits include higher yields, reduction in pesticide use, and more flexibility in managing weeds and other pests.
- The net reduction in pesticide use and safer foods—as well as major environmental benefits, the preservation of topsoil, and reduction in greenhouse gas emissions—are outcomes consumers support.

The export market, and its labyrinthine maze of regulations, remains an immense barrier to commercialization of GE crops and foods, especially to smaller companies and academics not familiar with the export structure and documentation requirements.

- European Union regulations are characterized by an ambiguous definition of genetically modified organism, an expeditiously flexible interpretation of the "Precautionary Principle," and an unnecessarily comprehensive case-by-case approach to environmental risk assessment.
- Although Canada's "plant with novel traits" policy is often hailed as the "scientifically sound" example for others, the policy is not without problems or controversy.
- China has a unique regulatory system combining both scientifically sound and politically motivated, scientifically unsound elements.

If regulatory compliance is difficult for large companies, small businesses and public institutions have almost no chance to commercialize safe, effective, and innovative GE crops and foods.

- The unnecessarily complicated, onerous, and unscientific regulatory system presents a near insurmountable barrier.
- Our current system denies potential benefits to farmers, consumers, and the environment, with no corresponding increase in safety, and unduly restricts innovation by public and private sector developers.
- Until regulations align with the stated public policy goal of reasonably assuring safety and regulating commensurate with the degree of risk posed, public, academic, and small business entities will continue to be frustrated in using these safe tools to deliver useful products to farmers and consumers.

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CAST Commentary QTA2017-1
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Why Does Bee Health Matter? The Science Surrounding Honey Bee Health Concerns and What We Can Do About It

A colony of honey bees is an amazing organism when it is healthy; it is a superorganism in many senses of the word.

- The individual bees that make up a honey bee colony deliver to the superorganism what it needs.
- Honey bees with access to better and more complete nutrition exhibit improved immune system function and behavioral defenses for fighting off effects of pathogens and pesticides.
- Bee colonies are chronically exposed to parasitic mites, viruses, diseases, miticides, pesticides, and poor nutrition.

Since 2006, there has been a tragic breakdown in honey bee health.

- Honey bees depend entirely on flowering plants for their nutrition.
- In turn, human nutrition depends heavily on honey bees for pollination of fruits and vegetables.
- Aside from the direct and indirect benefits derived from their pollination services, honey bees support diverse assemblages of plant communities that sustain wildlife and, intangibly, add to the quality of life.
- Some of our native bees, such as certain species of bumble bee, are in more severe decline than our managed honey bees, emphasizing the need for more research on native pollinators.

Most scientists agree that there are four main stressors all bees are facing: parasites, pathogens, pesticides, and poor nutrition.

- Parasitic *Varroa destructor* mites acquire and transfer bee viruses as they feed on and move from bee to bee.
- Exposure to pesticides in many areas is common, yet mechanisms for reporting colony losses and identifying the source of contamination are deficient and variable based on state and local government agencies.
- Good nutrition, which for bees comes from the landscape, is the foundation of a healthy, productive colony.

There are concrete ways that bees and beneficial insects could be protected from unwanted and unintentional pesticide exposure.

- One best management practice (BMP) is to curtail the off-target drift of all pesticides.
- The use of integrated pest management approaches in both grower and beekeeper operations is another BMP that will improve the timing and effectiveness of chemicals and decrease pesticide exposure on bees.
- Improvements could be made to pesticide labels and regulations to further decrease pesticide exposure on bees.
- Establishment and maintenance of publicly available, commercial pesticide-use records and apiary locations would allow beekeepers, researchers, and regulators to investigate bee incidents from pesticide exposure or eliminate pesticides as a potential cause.

The large proportion of privately owned lands in the United States highlights the role that landowner decisions play in the creation or elimination of habitat for honey bees, especially in rural parts of the country.

- It is imperative to provide clean sources of high-quality floral nutrition for bees in urban and agricultural landscapes.
- Land management activities and policy decisions that are informed through science will act to secure healthy populations of honey bees and wild pollinators over the long term, as well as a healthy and diverse agricultural food production system.

Finding solutions means realizing that there is a problem.

- Most scientists and beekeepers agree that honey bee health decline is the result of multiple stressors.
- Although some are simple enough, most of the stressors are interacting in nature.

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Approved Proposals for CAST Publications

ANIMAL AGRICULTURE AND ENVIRONMENTAL ISSUES

Antibiotic Use in Animal Agriculture: Impact on Animals, Consumers, and Antibiotic Resistance

GMO Free—The Impact on Consumers, Retailers, Farmers, and the Environment

Impact of Recruitment and Retention of Food Animal Veterinarians on the U.S. Food Supply

Impacts on Human Health and Safety of Naturally Occurring and Supplemental Hormones in Food Animals

Protecting Food Animal Gene Pools for Future Generations

Social and Economic Impact of Misinformation in Agriculture

Technologies on the Shelf—A Series Keynote Paper

FOOD SCIENCE AND SAFETY

A Review of the Economic and Environmental Impacts of International Trade

Big Data Arrives to Manage Agriculture and Food Safety

Conventional and Organic Food Production: Food Quality and Safety

Food Biofortification—Reaping the Benefits of Science to Overcome Hidden Hunger

Gluten Tales and Truths

Interpreting Agricultural Chemical Residues Measured in Food or Milk

Pesticides in the Diet of Infants and Children: Scientists' Review

Producing Food Products from Cultured Animal Tissues

Review of Mycotoxin Impacts: Balancing Economic Costs with Animal and Human Health Adverse Effects Worldwide

Scientific Evidence for the Risk/Benefits of Raw Milk

Surfactants in Agriculture

PLANT AGRICULTURE AND ENVIRONMENTAL ISSUES

Ground and Aerial Robots for Agricultural Production: Opportunities and Challenges

Integrated Pest Management (IPM) Programs Protect Human Health, Environmental Sustainability, and the Economy

Irrigation and Precision Crop Management Technologies

Recruiting and Educating Graduate Students to Become Researchers and Leaders in Global Agricultural Studies

The Impact of CAST—50 Years of Influence in Agriculture

The Microbiome's Positive Impacts on Crops

The Need and Challenge for Effective Stewardship of New Pest Management Technologies in Agriculture