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Policy approaches to energy and resource use in US agriculture

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Abstract

Improving energy and resource use in US agriculture begins with the soil. Healthy soils improve air and water quality, increase land productivity, help resist the effects of drought and floods, improve energy efficiency and enhance the ability to mitigate climate change. In 1993, the US Board on Agriculture concluded that national policy should seek to: conserve and enhance soil quality as a fundamental first step to improve the environment; increase the efficiency of nutrient, pesticide and irrigation use in farming systems; increase the resistance of farming systems to erosion and runoff; and make greater use of field and landscape buffer zones, all delivered through farm system management plans. Despite their detailed analysis and thoughtful approach, only a few of their recommendations were implemented. But now, calls from the scientific community to improve resource and energy use in agriculture are becoming more urgent in tone and could help drive policy reform. We review the reasons behind this rising sense of urgency, highlight some of the potential policy drivers along with policy 'game changers' and offer policy options. We argue to expand our view of agriculture as a source not only of food, fiber, biofuels and renewable energy but also of other critical ecosystem services, like cleaner water, carbon sequestration and wildlife habitat, and to adjust policies to realize this potential on all agricultural lands. We recommend undertaking a second National Agricultural Land Study as a basis to develop a clear national strategy to help US agriculture meet the challenges it will face in the coming decades. For the short term, we offer incremental policies to improve energy and resource use and, for the long term, we offer a vision of what that national strategy might include once the necessary analyses are completed and consensus is reached.

Key words: agricultural policy options, sustainable use of energy and resources in US agriculture, farm policy reform, multifunctional agriculture

Redefining Sustainable: Challenges for Resource and Energy Use Policy in the US

Both in the US and abroad, agriculture increasingly competes with other uses for land, water and biota[1,2]. Population growth, rising incomes and global climate change intensify this competition. The global population is projected to increase to 9 billion people by 2050[1]. Rising incomes may generate more demand for meat, increasing grain production[3]. Worldwide demand for feed grains could be more than double between now and 2050[4]. And global climate change will likely increase the demand for both biofuels and carbon sequestration in intact forests, while simultaneously stressing farms and forests with increased heat, drought and wildfires[1–3,5,6]. In addition, the global environment continues to experience toxic spillovers from energy supply, industry and agriculture[1,7]. A new global analysis predicts that our planet is approaching the boundaries for global freshwater use, change in land use, ocean acidification and interference with the global phosphorus cycle[7]. Three of the Earth-system processes (climate change, rate of biodiversity loss and interference with the nitrogen cycle) may have already transgressed their boundaries as a result of human activities[7].

The severity of climate change will be directly affected by the choices made curbing greenhouse gas (GHG) emissions over the next few decades[8,9]. Even if nations begin to address global warming aggressively, gases already trapped in the atmosphere will influence future weather patterns and the availability of water and other vital ecosystem services for centuries to come[6]. US agriculture is experiencing declining water tables, increased costs of water withdrawal and the deterioration of water quality linked to climate change[10]. Increasingly negative impacts from extreme weather events are likely to occur before 2050[11]. Projected increases in temperature, changes in rainfall amount and patterns, rising atmosphere concentrations of CO_2 and tropospheric ozone, and increases in extreme weather events will affect agricultural productivity[5,6]. The magnitude of effects will depend on agriculture's ability to adapt through future changes in technology and changes in environmental conditions such as water availability and soil quality[5,12]. Indeed, without an *unprecedented* increase in conservation practices and significant changes in cropping systems, these changes in temperature and rainfall could cause huge economic losses and severe damage[13].

Here in the US, our population is projected to increase by 50% to 450 million by 2050 and could go as high as 500 million through immigration[14]. If we follow current land-use trends, by 2050 the amount of arable land per capita in the US will decrease from about 1.6 to 0.7 acres per person, while global arable land will decrease from 0.56 to 0.39 acres per person[14]. But while the need to enhance agriculture productivity increases, so do pressures to improve resource use efficiency, maximize energy conservation, reduce GHG emissions and improve resiliency to weather extremes[15].

Policy Drivers

The challenges ahead for US agriculture are unprecedented yet we continue to rely on farm programs that were designed to deal with the issues of the 20th century and which may not provide the appropriate tools and incentives to address the challenges of this century[15–21]. In addition, other federal policies and programs on energy, the environment, climate change and nutrition increasingly affect agriculture and complicate the policy development process[15]. To succeed, new policies must respond to the 'policy drivers' listed below more effectively and convincingly than current policies. 'Policy drivers', as we define them in this paper, are issues or circumstances that either reopen policy debates or provide tools or scenarios that could make action to reform policies more likely. In some cases, as highlighted below, these policy drivers may evolve into policy 'game changers', which require policymakers to act. While these 'policy drivers' will have a substantial effect on energy and resource use in US agriculture in the future, each also comes with opportunities.

A more variable climate

The US Global Change Research Program recently reassessed global climate change impacts on US agriculture and concluded that productivity will increase in some regions and decrease in others[6]. Projected weather impacts from increased climate variability are numerous[5,6].

Opportunities. Managed carefully, climate adaptation strategies also benefit the environment since many involve improved resource management[22].

Pressure to address climate change

US agriculture represents 8.6% of the nation's total GHG emissions, including 80% of its nitrous oxide emissions and 31% of its methane emissions[6]. Bills pending in Congress establish a cap-and-trade system for GHG emissions, while excluding agriculture from the caps (limits) on GHG emissions applied to other industries[17]. Passage of a US climate change bill could be a 'game changer' for agricultural sustainability if it includes a significant offset market under cap and trade and an aggressive renewable electric standard that make it profitable for farmers and ranchers to sell carbon credits and produce low carbon energy. While agriculture is concerned about impacts on energy and input costs[17], some analyses project modest costs for agriculture in the short term and net benefits over the long term[23,24], because of its ability to sequester carbon and/or reduce methane and nitrous oxide emissions and sell the resulting carbon offsets to regulated industries. Several issues remain[25–30] and groups hope to reach consensus around them[31,32]. Because of the projected impacts of a variable climate on agriculture, inaction may be far more costly[33–36]. Although federal legislation has stalled, 23 states are participating in regional partnerships that require reductions in GHG emission. In addition, three voluntary carbon-offset programs accept, or are considering, carbon offsets from agriculture[37].

Opportunities. Agricultural practices that reduce GHG emissions offer multiple economic and environmental benefits[38]. For example, reducing field operations saves money, time and labor, while reducing fossil fuel use and soil organic carbon loss[38]. Improving nutrient management and substituting renewable organic nutrients for fossil fuel-based nutrients can reduce emissions, while maintaining yields and addressing water-quality issues[38]. Better management of nitrogen fertilizers could reduce nitrous oxide emissions and result in fewer nutrients reaching ground and surface waters[38]. Sequestering carbon in soils can increase resiliency to climate change, improve yields, deliver co-benefits and buy us time until alternatives to fossil fuels take effect[39]. Recently, the European Union identified agricultural practices that mitigate GHG, provide environmental benefits and avoid societal, technical or economic trade-offs[40].

Increasing demand for biofuels and renewable energy and rising fossil fuel costs

The Energy Independence Security Act sharply increased the requirements for future use of ethanol, biodiesel and 'advanced' biofuels (to 36 billion gallons by 2022) and the 2008 Farm Bill added additional 'incentives'[17]. But biofuels face some hurdles. EPA has proposed considering 'indirect land use' effects when calculating GHG emissions associated with advanced biofuels[8]. The agency is concerned that more land may be brought into cultivation, releasing sequestered carbon[41]. This claim has been challenged[42,43] but biofuels could also displace food crops and drive up the price of grain available for livestock production[3]. In the long term, using biomass or cellulosic ethanol may avoid some of these side effects[44,45], but the need to balance energy yields, carbon implications and the full impacts of biofuel production on downstream and downwind ecosystems remains[45,46]. Near term, obtaining high grain yields with high efficiency will be critical to achieve a favorable energy balance and an adequate grain supply[42,47]. Average nitrogen fertilizer uptake efficiency for grain production is less than 40% of applied N[48]. At the same time, energy costs will continue to rise, with light sweet crude oil in the US predicted to rise from $61 per barrel in 2009 to $110 per barrel in 2015 and $130 per barrel in 2030[49].

Opportunities. Management practices that increase soil organic matter or alter organic matter composition to achieve better synchrony between soil net-N mineralization and crop demand provide efficiency benefits and improve the delivery of ecosystem services over the long term[48,50].

The market for farm-based renewable energy remains modest with on-farm energy costs, long-run supply challenges and regulatory and technological barriers impeding the adoption of many alternative energy systems[51,52].

Opportunities. Anaerobic digesters (or methane digesters) could reduce both GHG emissions and nutrient loadings to waterways and generate additional income for struggling dairy producers, but require large capital investments, considerable technical knowledge plus management time and expertise to operate, and entail considerable business risk[52]. Lower-tech alternatives exist but remain under-researched and under-utilized in the US, as Welsh and colleagues show in this issue.

The budget deficit

The current administration recently proposed phasing out direct payments to farmers with revenues above $500,000. Although this was strongly rejected by Congress, agriculture faces 'budget reconciliation' as Congress periodically reorders its fiscal priorities[17]. Privately, farmers and farm state lawmakers acknowledge the need to adjust the current farm programs[17]. Continuing budget deficits could emerge as a 'game changer' if there is a budget reduction agreement that forces significant spending cuts in farm subsidy and conservation programs.

Opportunities. Reorienting farm policy to conserve and manage ecosystem services from agriculture could produce real and compelling benefits for taxpayers and the environment[20,50].

Continuing threat of regulation

Historically, the regulation on non-point source polluters such as agriculture has been voluntary[53]. A recently published Executive Order from the Obama administration and pending Total Maximum Daily Loads regulations are pressuring farmers in the Chesapeake Bay to improve nutrient handling[54]. The Chesapeake Bay could become a model for how the administration deals with water-quality issues in other large watersheds such as the Mississippi, Sacramento, Great Lakes and Puget Sound. In addition, the use of fertilizers is likely to come under heavier scrutiny because of the airborne impacts of nitrous oxide, a very potent GHG[45].

Opportunities. Changing tillage practices, improving soil quality, enhancing nutrient management and technology and adding more practices to sequester carbon will help prevent nutrients and soil sediments from leaving fields and improve nitrogen efficiency use.

Development of performance metrics

In 1993, The Board on Agriculture recommended that EPA and USDA develop *quantifiable standards* to help evaluate the management of farming systems[16]. Instead, demands from food processors, purchasers and consumers to know more about how their food is produced led to certification programs based on a priori determinations on technologies, practices and solutions[55,56]. These efforts are now shifting to performance metrics[57]. The 'Farm to Market' commodity crop project and the 'Specialty Crop Sustainability Index' are developing performance metrics and designing tools to help producers manage what they measure[58]. The Iowa Soybean Association uses field measurements to help farmers optimize their environmental performance, while maintaining or improving yields and profitability, and now includes over 400 producers in nine watersheds[59]. Work is also underway on a voluntary national sustainable agriculture standard that uses metrics to submit to the American National Standards Institute[60] and industry giant Walmart is developing metrics specifically for agriculture for use by its suppliers[61].

Opportunities. Linking energy and resource conservation practices to measurable outcomes provides producers with flexibility in meeting outcomes and brings us closer to quantifiable standards.

Shifting research priorities and producing better data

The USDA Cooperative State Research, Education, and Extension Service Long-Term Agricultural Research Program includes research on resiliency, ecosystem services and agricultural systems that maximize energy conservation, reduce GHGs and encourage mitigation[62]. In addition, a multi-agency effort is underway at the federal level to quantify the environmental benefits of conservation practices[63] and USDA's Sustainable Agriculture Research and Education program provides increasingly robust and diverse data on integrated farming systems and conservation practices that are profitable, environmentally sound and linked to outcomes[64].

Opportunities. A better understanding of how agricultural systems can balance competing needs, along with data linking practices to environmental benefits, should help us design more effective policies.

Escalating pressure from the international community and agricultural investors

Efforts by the international community to engage agriculture to improve its energy and resource use[22,65] may put more pressure on the US to begin reforming policies and provide useful blueprints for the US to follow. Both the United Nation's Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change have analyzed the challenges and opportunities for mitigation of GHG emissions by agriculture and have recommended policies and programs (although a US-focused analysis might reach different conclusions)[66,67]. At the same time, agricultural investors express concerns about climate change[68,69].

Opportunities. A new policy framework that encourages the mitigation of GHG emissions might align the US more closely with its trading partners and potential investors.

Emerging private markets for ecosystem services

Private markets have emerged for the environmental services offered by some farms. Worldwide, ecosystem service markets hover between proof-of-concept and early adoption[70]. Early projects show that agriculture may cost-effectively deliver ecosystem services that would otherwise require industry to install costly infrastructure upgrades to meet regulatory requirements. For example, in the Great Miami River watershed, the watershed-wide average per unit cost to reduce phosphorus for wastewater treatment plant upgrades was estimated at $23.37/pound compared to $1.08/pound for agriculture; and to reduce nitrogen, point source unit costs were $4.72/pound compared to $0.45/pound for agriculture[71]. There are 57 water-quality trading programs worldwide, 51 are in the US, 33 allow point–non-point source trades, and 26 are active, 21 are pending and 10 are inactive or are completed pilots with no plans for future trades[72]. Most address nutrient reductions and a few address selenium discharge, sedimentation and water flow. Opportunities for producers to sell nitrogen and phosphorus credits exist, respectively, in 142 and 224 of 710 nutrient-polluted watersheds[73].

Opportunities. Private markets put a value on environmental services, treat these services as commodities, diversify revenue streams for producers and reinforce the concept of farms as managed ecosystems[74].

Policy Recommendations

Positioning farms as managed ecosystems has been posed as the 21st century policy challenge[19,74]. Indeed, shifting the primary focus of US farm policy to conserve ecosystem services across farm and ranch lands not only creates a flexible policy framework that helps balance competing needs but the right mix of incentives and regulations could help over a billion acres of farm and ranch land deliver a vast and timely array of services that benefit the environment, society and individual farmers[19,50]. These include provisioning services of food, fiber, wood, fuel and fresh water; regulating services like buffering the effects of natural flooding; cultural services like recreation; and supporting services like cycling organic matter and transforming solar energy into plant matter[2,74–76]. For the individual farmer, managing for ecosystem services could reduce the need for costly inputs while enhancing yields[50]. One suggested approach to developing a framework includes placing farmland in its ecological, geographic and economic contexts; examining and assessing the capacity of existing property rights, regulations and social norms; and identifying the policies needed[77].

Informed discussion about ecosystem services by the lay public and policy-makers is just beginning[75,78], but the policy 'game changers' we outline above may ultimately favor this approach[19]. Taking ecosystem services into account would help producers balance necessary increases in productivity with increases in resource efficiency use and improvements in resiliency. If we took this bold step, we might appeal to a broader cross-section of society (particularly those swayed more by economic arguments than by environmental concerns); show a greater return on policy investments with the delivery of more services; develop new economic markets to protect land and water; diversify revenue streams for producers; and improve environmental policy by establishing criteria that more fully account for the impacts of alternative policies[19,78]. With this in mind, we recommend the following options to address the challenges of this century:

1. *Undertake a second National Agricultural Land Study*: The US Secretary of Agriculture and President's Council on Environmental Quality commissioned the first National Agricultural Lands Study (NALS) in 1979, a two-year project involving 12 federal agencies, to document the extent and causes of the loss of agricultural lands[79]. Pressure from public-interest groups, state legislators and farm organizations, a pending bill in Congress calling for such a study and personal support from USDA Secretary Bergland provided the impetus behind NALS[80]. We recommend broadening the focus in a second NALS to include all of the services that could potentially be offered by farm and ranch land, linking them to need and predicting future impacts. Such an analysis might combine elements of national land-use imaging[81], the original NALS study[79] and the Resources Conservation Act Appraisal process[38].
2. *Develop a clear national strategy*: Farm Foundation laid out a 30-year challenge[15] that recognizes US agriculture's strategic role in feeding and fueling a growing world, while dealing with financial markets and recession, food security, energy security, climate change, competition for natural resources and economic development. The report concludes: 'The United States

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currently lacks a clear strategy for meeting the 30-year challenge. A clear statement of goals that recognizes the global nature of the problems facing U.S. agriculture, the high levels of uncertainty surrounding many of these problems, the shift to an era of multiplying demands, increasing competition for resources, and climate change could lead to more consistency in both public- and private-sector decisions. Policy consistency could lead to fewer counter-productive, unintended consequences and more effective use of scarce resources, both natural and financial'[15]. Armed with the results of NALS2, this same group should then lay out *a comprehensive strategy* that preserves and enhances ecosystem services from farm and ranch lands and helps agriculture thrive in an era of multiplying demands.

For the short term:

1. *Prioritize conservation practices that most cost-effectively deliver co-benefits*: Completing a NALS2 study and developing a national strategy will take time, so we should aspire to achieve WTO-compliant changes in the 2012 Farm Bill[82]: reduce GHG emissions from large-scale livestock operations, promote reforestation, support co-generation of energy on farms, couple direct payments to environmental performance[20,83] and tailor existing subsidy systems to encourage change as part of a comprehensive environmental program [for example, requiring conformance with environmental performance standards in order to receive subsidies or direct payments (cross-compliance)][20,82–84]. We recommend prioritizing conservation practices and techniques that mitigate GHG, improve the resiliency of agriculture and also provide environmental benefits, while avoiding societal, technical or economic trade-offs.
2. *Target assistance and efforts to problem areas*: Better targeting means directing technical assistance, educational efforts, financial resources and regulations at regions, watersheds and areas where soil degradation and water pollution are most severe[16,20,21,85,86]. We now know a lot more about where we need to focus resources. For example, agriculture practices in just nine states along the Mississippi River contribute 75% of the nitrogen and phosphorus pollution to the Dead Zone[87]. Although politically challenging[86], shrinking budgets and pressure for better environmental outcomes might make targeting a bit more palatable.
3. *Continue to remove the barriers to voluntary adoption of improved farming systems*: On the whole, federal policies still continue to work against practices that generate ecosystem services, such as crop rotations, certain soil conservation practices, reductions in pesticide use and increased use of biological and cultural means of pest control[16,86]. In addition, the real or perceived fear that conservation practices might affect crop yields argues for expanding efforts to overcome this barrier and implement approaches that mitigate risks and offer yield guarantees like that used by American Farmland Trust[88].
4. *Provide regulatory relief to producers who implement valid farm system management plans*: Producers who implement a valid farm system management plan should be immune from lawsuits or enforcement actions. In addition, farmers participating in ecosystem service markets should be eligible for regulation relief if they meet appropriate baseline standards. This requires a greater focus on whole-farm assessments and farm system management plans that encourage continuous improvements. These plans should maximize ecosystem services from farm operations, using emerging performance metrics tools that provide farmers flexibility in deciding what practices to employ.
5. *Continue to help agriculture tap into emerging markets for ecosystem services*: The 2008 Farm Bill created a new office of Ecosystem Services and Markets to help establish technical guidelines for emerging ecosystem services markets[74]. Along with technical guidelines, emerging markets may also benefit from: enforcing regulations (for example, numeric water-quality standards or a cap on carbon emissions); encouraging intermediary institutions that can help farmers in these new markets (e.g., provide technical assistance; act as aggregators on both ends, for both buyers and sellers); reassuring financial lending institutions that practices and income streams will last for the life of the loan; and dealing with market scale issues[78]. Some markets will be national or global in scope, while other markets will be quite local and unique with significant transaction costs and may need help from the federal government[89].
6. *Build a technical services infrastructure suitable for environmental management*: Producers need assistance to improve their environmental management, develop farm system management plans, use information-intensive technologies and reach 'late adopters' [90,91], but US agriculture is rapidly losing the capacity to 'get conservation on the ground'[20,92]. Capacity-building argues for a coordinated investment plan that couples the new Commodity Credit Corporation funding with strategic increases in discretionary funds for research, education and technical assistance and allocates those resources to federal, state, local government, non-governmental organizations and the private sector based on their ability to deliver[20,38].
7. *Significantly increase public investment in agricultural research*: Investments in US agricultural research have an average annual economic rate of return to the public of 53%[93], but to meet future challenges, the public would benefit from greater investments in research that enhances agricultural productivity while improving resource use efficiency, maximizing energy conservation, reducing GHG emissions, mitigating GHGs and improving resiliency to weather extremes.

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One vision for the longer term:

1. *Establish a land stewardship standard*: Use the findings of NALS2 and the goals set in the new national strategy to establish clear performance standards and encourage innovation. The resulting 'land stewardship standard'[19] would apply to all producers regardless of changes in market prices, ownership of the land, production systems, the structure of the farm enterprise or the goals of the producer, providing the permanence in requirements that most producers seek[16]. Farm system management plans would help producers meet the land stewardship standards. The standards would most likely encompass the decades-old Board on Agriculture recommendations[16]. Although the costs of this approach have not been calculated, when USDA NRCS analyzed conservation alternatives in 2001, the total societal costs of the highest level of conservation applied nationwide were $6.4 billion/year, providing environmental benefits of $10.7 billion at a benefit/cost ratio of 1.7[38]. In comparison, farm commodity and price support programs averaged nearly $15 billion annually from 1995 to 2004[94]. Direct government payments for income support reach about 25% of all farms[95].
2. *Use a whole-farm stewardship agreement to deliver coordinated programs and services*: Instead of pitching a confusing array of separate programs and services to farmers and ranchers, use one agreement to deliver them to the landowner or operator. A whole-farm stewardship agreement would: determine whether a farmer meets the land stewardship standard (or needs technical assistance to meet it); help achieve the conservation priorities in the local watershed; make a range of programs available to the farmer; and set performance criteria[19,83].
3. *Align federal farm support with the production of public goods such as environmental services and use regulatory approaches when warranted*: Any federal farm support should complement the ecosystem services framework. Regulatory approaches may be warranted to address: (1) areas where soil and water-quality degradation is severe and (2) problem farms that are unacceptably slow in implementing improved farming systems to meet the land stewardship standard[2,85].

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