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Public Goods and Externalities: Agri-environmental Policy Measures in the United States

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Abstract

PUBLIC GOODS AND EXTERNALITIES: AGRI-ENVIRONMENTAL POLICY MEASURES IN THE UNITED STATES

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Agriculture is a provider of commodities such as food, feed, fibre and fuel and, it can also bring both positive and negative impacts on the environment such as biodiversity, water and soil quality. These environmental externalities from agricultural activities may also have characteristics of non-rivalry and non-excludability. When they have these characteristics, they can be defined as agri-environmental public goods. Agri-environmental public goods need not necessarily be desirable; that is, they may cause harm and can be defined as agri-environmental public bads.

Public Goods and Externalities: Agri-environmental Policy Measures in the United States aims to improve our understanding of the best policy measures to provide agri-environmental public goods and reduce agri-environmental public bads, by looking at the experiences of the United States. This report provides information to contribute to policy design addressing the provision of agri-environmental public goods including the reduction of agri-environmental public bads. It is one of the five country case studies (Australia, Japan, Netherlands, United Kingdom, and United States), which provide inputs into the main OECD book, *Public Goods, Externalities and Agri-environmental Policy Measures*.

Keywords**:** public goods, externalities, agri-environmental policies, United States

JEL classification**:** Q52, Q53, Q54, Q56, Q57, Q58

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Executive summary

Since the 1960s a mosaic of federal, state, and local programmes that are explicitly intended to encourage positive environmental externalities and diminish negative externalities associated with agricultural production has evolved. Federal legislation provided the USEPA with authorities for controlling air and water pollutants that result from agricultural production. Environmental objectives and initiatives were added to federal conservation programmes administered by the USDA beginning in the 1970s and have been expanded substantially since the 1990s. State and local governments have also been active in developing programmes to influence the supply of agri-environmental public goods and externalities. These programmes are in some cases undertaken to comply with federal mandates, but are often the result of initiatives to address specific state or local concerns.

Agri-environmental policies in the United States target soil quality, air and water quality, water quantity, wetlands, wildlife, and agricultural landscapes. Some programs are intended to increase the supply of such goods by encouraging or mandating practices that are less harmful to the environment than current practices on working lands. Others are intended to increase the supply of such goods by converting environmentally sensitive agricultural lands to permanent vegetative covers, preventing or limiting the conversion of environmentally sensitive lands to agricultural production, and limiting conversion of agricultural land to more developed uses.

United States' agri-environmental programmes are providing environmental benefits that are valued by citizens. Noteworthy accomplishments include reductions in pesticide risks to the environment, improvements in soil quality protection, and a reversal of the negative impacts of agriculture on wetlands areas and wildlife habitat.

Water quality is, however, an area where current agri-environmental policies are not achieving established goals, leaving agriculture as a leading cause of water quality problems. Policy reforms to increase the effectiveness of water quality protection from agricultural nonpoint pollution are essential for national progress on water quality.

United States agri-environmental policies are not necessarily cost-effective. Existing policy designs do not adequately target resources to locations and activities according to potential environmental benefits, focus on effort rather than environmental outcomes, and in the case of negative externalities, allow producers too much discretion about their environmental performance. Policy reforms to improve cost-effectiveness could help address the slow progress of water quality protections, and help address pressures on agri-environmental public goods provision that may emerge with federal and state budgetary pressures.

1. Introduction

Until recently the goods resulting from agricultural production would be described in the United States as conventional agricultural commodities – milk, meats, eggs, fruits, vegetables, grains, and fibres. Beginning in the 1960s the conception of the goods from agriculture began to change as it was recognised that agricultural activities, including conversion of land to or from agriculture, have "off-farm" environmental consequences. Attention was initially focused on adverse impacts on water quality resulting from runoff carrying pesticides, fertilisers, and soil eroded from intensively tilled lands, into water resources. The catalogue of environmental conditions affected by agricultural production has been refined and expanded with improved understanding of the relationships between agricultural land use and the environment, and the environment as affected by agriculture, and human well-being. This catalogue includes beneficial impacts of agriculture as well as the negative impacts.

Unlike conventional agricultural commodities, the environmental "goods" affected by agriculture are generally not "private goods" that can be traded in well-functioning markets. Instead, they are typically "public" or "quasi-public goods" subject to market failure. The joint production of a public good (or bad) with a market good is a classic source of externality (Cornes and Sandler, 1996). The effect of agricultural activities on environmental conditions is a classic example of this externality type (OECD 1992, 1999, 2013a; Ribaudo et al., 2008). Markets provide agricultural producers with prices for traditional commodities, but not for jointly produced "outputs" (e.g. polluting emissions) that the affect off-farm environmental conditions. The expected result without policy intervention is oversupply of negative environmental externalities and undersupply of beneficial environmental externalities (Cornes and Sandler 1996).

Prior to the 1970s, agricultural laws and programmes in the United States were largely intended to serve policy objectives related to agricultural productivity, farm income, commodity prices, agricultural trade, and rural economic vitality (Shortle and Abler, 1999). Environmental externalities associated with agricultural production were generally unrecognised or not considered public policy issues, until the emergence of public demands for environmental protection, and recognition that agricultural practices could pose environmental risks in the 1960s. National programmes directed at inputs or activities that are today considered as important determinants of agri-environmental externalities existed, but served other objectives. For example, national insecticide regulation programmes initiated with the Federal Insecticide Act of 1910 were to protect farmers from fraud in the insecticide supply chain. National conservation programmes administered by the United States Department of Agriculture (USDA) were initiated in the 1930s to promote soil quality protection on farms and ranches, with the primary objective of protecting agricultural productivity and sustaining agriculturally dependent rural economies. Similarly, state governments established contract, property, and estate laws necessary to conduct farm business, but did not regulate agriculture's impacts on the environment.

The Rubicon of public policies for agri-environmental public goods and externalities in the United States was crossed with the 1972 Federal Environmental Pesticide Control Act. This legislation, which superseded the 1910 Federal Insecticide Act, made environmental and public health protection the primary objectives of pesticide regulation, and transferred responsibility for regulation from the USDA to the newly created United States Environmental Protection Agency (USEPA). The Clean Air Act of 1970 and the

Clean Water Act of 1972 provided the USEPA with authorities for controlling air and water pollutants that result from agricultural production. Environmental objectives and initiatives were added to the suite of federal conservation programmes administered by USDA beginning in the 1970s and have been expanded substantially since the 1990s. State and local governments have also been active in developing programmes to influence the supply of agri-environmental public goods and externalities. These programmes are in some cases undertaken to comply with federal mandates, but are often the result of initiatives to address specific state or local concerns that are not addressed by federal policy. The result is that there is today a complex mosaic of federal, state, and local programmes that are explicitly intended to encourage positive environmental externalities and diminish negative externalities associated with agricultural production.

This report presents a review United States agri-environmental policies. Topics addressed include: the agri-environmental public goods that are targeted by agri-environmental policies in the United States, how these agri-environmental public goods are provided in United States agricultural system; the market failure associated with these goods; the extent farmers should bear costs for providing these agri-environmental public goods, and to what extent the society bear the costs; and the kinds of agri-environmental policy measures that are implemented in the United States to address the market failures.

2. Agri-environmental public goods targeted in the United States

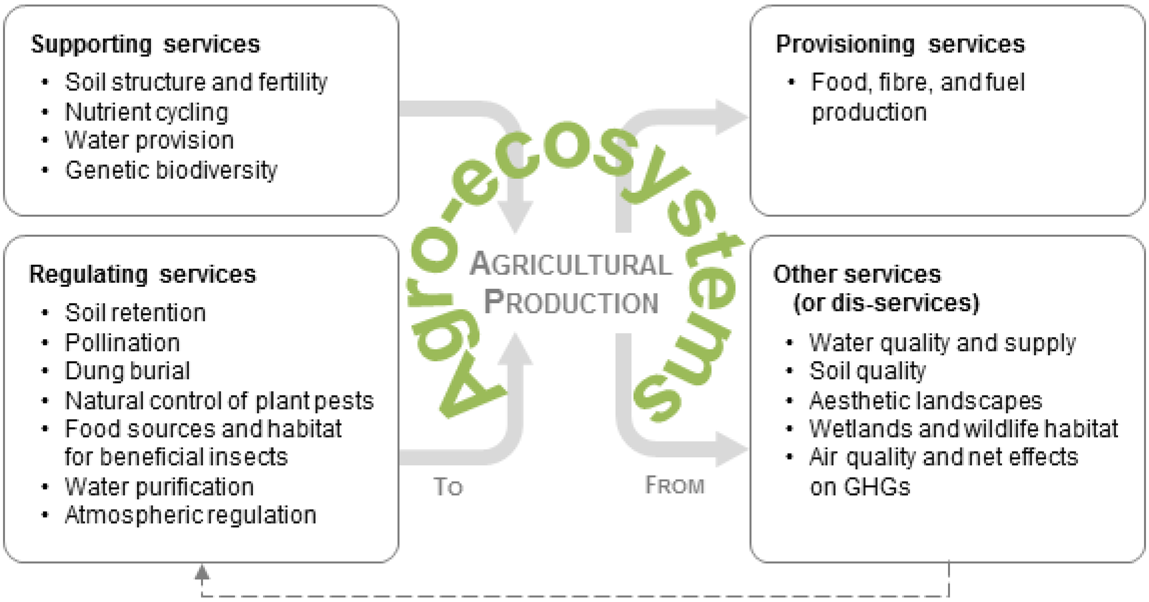
2.1. The domain of agri-environmental public goods

Advances in sustainability science have led to significant new understandings of the relationships between land use, landscapes, the products and productivity of managed and unmanaged ecosystems, and human wellbeing over the past several decades, and a new paradigm for conceptualising these relationships. This paradigm, introduced in the 1990s and succinctly articulated in the 2005 Millennium Ecosystem Assessment (MEA), presents managed and unmanaged ecosystems as providing ecosystem services (Daily, 1997; MEA, 2005).

Ecosystem services are benefits that people receive directly or indirectly from ecosystems. These include provisioning services (e.g. food, fibre, fuel, and water), regulating services (e.g. regulation of floods, drought, land degradation, and disease), supporting services (e.g. soil formation, nutrient cycling); and cultural services (outdoor recreation, aesthetics, nonmaterial benefits) (MEA 2005). Within this paradigm, agricultural production takes place within agroecosystems that encompass the crops, pastures, livestock, other flora and fauna, soils, water, and the atmosphere and their interactions on the land in which agricultural activity takes place and beyond to include systems affected by farming activity. These agroecosystems are contained within and interact with larger landscapes, which include uncultivated land, drainage networks, and wildlife. The emergence of agroecoystems as an ecosystem type reflects the profound impact that agricultural activity has on the surrounding landscape (Heinz Center, 2003; MEA, 2005). Within the taxonomy of ecosystem services, agroecosystems serve first and foremost to provide "provisioning services," which are the food, fibre, and energy products from agricultural enterprises (Figure 1). Agroecosystems depend on supporting and regulating ecosystem services for their productivity, and agricultural production activities in turn influence these and cultural services as well (Swinton et al., 2007; Zhang, 2007; Power, 2010). Agriculture's provisioning services are conventional market goods. Agriculture's effects on supporting, regulating, cultural services are nonmarket impacts on the flow of these environmental public goods (Figure 2).

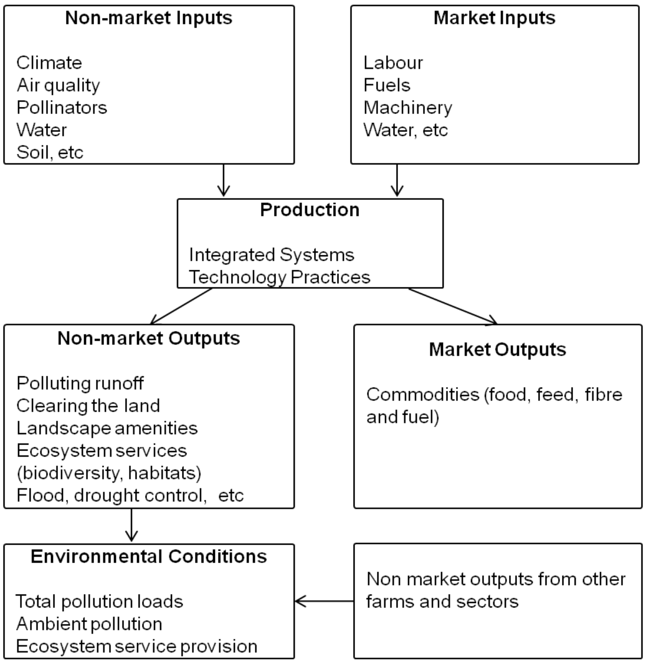
Within the broad categories of ecosystems services, there are numerous specific types of services. Some relevant to agriculture are pollination, carbon sequestration, water regulation (e.g. aquifer recharge), water filtration, and wildlife habitat. Such specific services when affected by agricultural activities define the domain of agri-environmental public goods. US agri-environmental policies target a subset of goods within the wider domain. A deep understanding of the specific choices can be learned from the history of relevant legislation and the subsequent administration of agri-environmental policies. As a practical matter, governments can be expected to give priority to agri-environmental public goods according to their relevance to prominent environmental concerns (e.g. air quality, water quality, and endangered species), the state of scientific knowledge about relationships between agricultural activities and environmental conditions, and the capacity of government agencies to measure, monitor, and manage these relationships.

Figure 1. Ecosystem services and dis-services to agriculture



Source: Blandford, D., J. Braden and J. Shortle (2014), "Economics of Natural Resources and Environment in Agriculture". Chapter 122 in N. van Alfen (eds.), *The Encyclopedia of Agriculture and Food Systems*. Adapted from Zhang, W., T. Ricketts, C. Kremenc, K. Carney, and S. Swinton (2007), "Ecosystem Services and (Dis-Services) to Agriculture". *Ecological Economics*. Vol. 64, pp. 253-260.

Figure 2. Agricultural production and agri-environmental externalities



1. Artificial markets can be created for some non-market inputs/outputs (e.g. tradeable permit markets for polluting runoff).

2.2. The federal structure of agri-environmental policies

Essential to an understanding of the choice of the agri-environmental public goods targeted in the United States, and to an understanding of the mechanisms used to provide those goods, is recognition of the federal structure of environmental legislation, administration, and enforcement. This structure entails a division of responsibilities for agri-environmental public goods, across national, state, and local authorities, delegation of federal authorities to state and local governments for implementation, overlapping programmes across levels of government, and the multiple agencies with authorities for agri-environmental policies at various levels of government. Underlying this structure are the powers delegated to the federal government and to the states under the United States Constitution. The "Supremacy Clause" of the Constitution establishes federal laws as the "supreme law of the land" when Congress legislates within its constitutionally authorised powers.

If Congress has not acted in a particular area, then states may choose to do so if empowered by the state constitutions. Local governments such as counties, municipalities, are creations of the states, and exercise authorities granted to them, primarily through zoning uses or other permitted activities in designated places. Table 1 shows the structure of agri-environmental policies in the United States.

Congressional environmental legislation in the 1970s asserted federal authority to regulate the environment and substantially nationalised air quality, water quality, and some other aspects of protection. Essentially, this nationalisation entailed the federal government selecting a suite of environmental public goods for protection, establishing goals for their protection, and mechanisms for pursing them. Agriculture is sometimes a regulatory focus of environmental legislation, as in the case of USEPA regulation of pesticide use, but it is more often the case that agriculture is exempt or excluded from federal environmental regulation (CRS, 2013). The implementation of federal environmental laws is generally undertaken cooperatively with the states. Permitting, inspection, and enforcement activities required by national environmental regulations are often delegated to and implemented by state, local, and sometimes tribal governments subject to USEPA approval, regulatory guidance and oversight. State regulation of agricultural activities that are not directly mandated by federal law can result from the choices of states in their implementation of federal law. For example, the Clean Water Acts (CWA) delegates responsibility for agricultural nonpoint water pollution management to the states and does not require any regulation of agriculture, but states may, and some do, choose to implement water quality regulations for agriculture.

Table 1. Structure of US Agri-environmental Policies

Federal Government: Provides the "supreme law of the land" on agri-environmental public goods where Congress legislates within its constitutionally authorised powers	
US Department of Agriculture	Primary federal agency for provision of agri-environmental public goods of all types (Omnibus "Farm Bill" legislation typically passed on a 5 year cycle. Most recently, the Agricultural Act of 2014).
US Environmental Protection Agency	Primary federal agency for pesticide regulation (Federal Insecticide, Fungicide, and Rodenticide Act), and for enforcing federal air and water pollution control laws (Clean Air Act, Clean Water Act Coastal Zone Act Reauthorization Amendments). Agriculture is largely exempted from direct federal air and water quality regulation.
US Fish and Wildlife Service	Authorities related to endangered species protection (Endangered Species Act).
US Army Corps of Engineers	Authorities related to wetlands protection (Clean Water Act).
State and Local Governments: (1) Authorities delegated to state, local, and sometimes tribal governments by the federal government in areas where federal law is supreme; (2) State and local agri-environmental policy initiatives (sometimes undertake collaboratively with the federal government) in areas that are not contradictory to federal law in regulatory domains covered by federal law; (3) States and local initiatives in areas that have not been pre-empted by federal legislation.	
State and local governmental structures vary. **Most have agencies for agriculture, environment, and natural resources. Land use management is often conducted at local levels.**	The Clean Air and Clean Water Acts delegate significant water pollution control authorities relevant to agriculture to the states. State and local agencies work collaboratively with federal agencies to implement USDA and other federal agri-environmental laws and programmes. State and local agencies are the primary actors for protecting agricultural landscapes.

The most important federal agri-environmental programmes are not those resulting from federal environmental laws but those resulting from federal agricultural legislation establishing programmes with agri-environmental objectives administered by the USDA. Other federal agencies with programmes of consequence for the pursuit of agri-environmental public goods are the US Fish and Wildlife Service (endangered species), and the US Army Corps of Engineers (wetlands).

State responsibilities for agri-environmental public goods are sometimes mandated by national laws. An important example is the delegation of responsibility for agricultural nonpoint pollution control under the CWA to the states. Federal environmental statutes generally recognise that the protection of the environment is an appropriate exercise of the power to protect the health, safety, and welfare of their state citizens and generally allow states to take actions at their own initiative that are not contradictory to federal law in regulatory domains covered by federal law. And, states can undertake actions without constraint from federal environmental laws in areas in which they have not been pre-empted by federal legislation.

An important example is farm land preservation. Many states have implemented programmes, and established authorities for local governments, intended to regulate conversion of farm land to more developed uses. Such regulations were initially justified as measures to protect agricultural productivity, but increasingly they are viewed as serving other purposes, including preservation of rural landscape amenities, habitat and biodiversity protection, and control of urban spread. States also variously enact measures to regulate agricultural nuisances (e.g. odours, flies), or to protect farmers from law suits resulting from such nuisances, or a body of law has often been developed through the court system. Surface and ground water management is another domain in which the states play a major role.

2.3. Targeted agri-environmental public goods

Reviewing major agri-environmental policies in the United States with environmental objectives, this study finds 6 agri-environmental public goods targeted by federal and states governments (Table 2).

Table 2. Main agri-environmental public goods targeted in the United States

	Soil quality	Water quality	Water quantity	Wetlands and wildlife habitats	Agricultural landscapes	Air quality
Federal	XXX	XXX	XXX	XXX	XX	X
States	XX	XX	XXX	XX	XXX	X

XXX: main actors taking responsibilities for agri-environmental public goods.

XX: sub actors taking responsibilities for agri-environmental public goods.

X: not leading environmental concerns so that federal and states governments take limited responsibilities for agri-environmental public goods.

Soil quality was established as a major agri-environmental target by federal legislation in the 1930s. This legislation established the Soil Conservation Service (now the Natural Resource Conservation Service (NRCS)) and led the development of an array of soil quality programmes. The NRCS works cooperatively with Soil and Water Conservation Districts (or other similarly named entities) which are sub-state level government units created by state governments to pursue soil quality goals. The catalyst for soil quality programmes was the "Dust Bowl" of the 1930s, named for enormous dust storms originating in the Great Plains that would cover large expanses of the nation. The dust was soil eroded from croplands, converted from native grasslands after an extended drought combined with poor conservation practices left bare soils exposed to wind. Agricultural and resource management agencies in states also variously pursue soil quality goals in agricultural contexts.

The leading contemporary agri-environmental issue in the United States is **water quality**. Of particular importance to agri-environmental programmes are public policy objectives for surface water quality. The CWA of 1972 was a response to the highly degraded state of surface water quality and the failure of prior federal and state water quality programmes to protect water quality. It set a national goal of restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters, with an interim goal that all waters be fishable and swimmable where possible. Of particular significance to agriculture is that the CWA requires the states to establish water quality standards for waters within their jurisdictions. States are required to periodically assess the condition of surface waters relative to the standards. Waters that fail to meet standards are designated as impaired. The CWA requires that states develop a restoration plan, defined as a Total Maximum Daily Load (TMDL), for impaired waters. A TMDL identifies pollutant load limits necessary to achieve water quality standards, and allocates the limit across various sources, including agricultural sources where applicable. Concerns for water quality relevant to agriculture are also reflected federal pesticide regulations, wetlands protections, and in state initiated water quality programmes.

Water quantity is considered a targeted agri-environmental public good due to the extensive pressure on freshwater resources associated with agriculture, the investments in infrastructure for irrigation, extensive development of water management laws, institutions, and programmes by the federal and state governments, and on-going water quantity challenges. Irrigation is essential for agricultural production in some regions of the United States, particularly the arid Western States. Across the United States, agriculture accounts for 80% of consumptive water use. Challenges include increasing demand for water from alternative uses, depletion of ground waters, inefficiencies in water allocation, and climate change impacts on supplies and variability. Increased demand comes from population and economic growth, but also occurs from the allocation of water to newly recognised in-stream services (e.g. aquatic ecosystem protection, water-based recreation), energy development, and emerging Native American water rights. Irrigation return flows also pose water quality problems in some regions. Increasing demands from and allocation to alternative uses have led to water conservation and improved efficiency of water use in irrigated agriculture being an agri-environmental policy goal in federal policy pursued through USDA conservation programmes.

Wetlands provide a host of ecosystem services, including providing habitat for birds, reptiles and amphibians, fish, insects, and plants, storing floodwaters, filtering pollutants, serving as a carbon sink, and providing recreation sites. Federal policies intended to explicitly protect wetlands from agricultural development and foster wetlands creation on agricultural lands began in the mid-1980s with inclusion of wetlands protection measures in federal agricultural legislation administered by USDA. This and other federal initiatives for restoration and protection of wetland emerged from attention to the enormous losses of this land use type as a result of agricultural and other development, and improved understanding of the environmental significance of wetlands. A landmark in federal wetland's policy wars President Bush's establishment of a "no net loss" policy in 1988. States address wetlands through federal mandates and in pursuit of their own objectives.

Policies to restore and protect wetlands are part of a broader concern for the restoration and protection of environmentally significant land uses and related ecosystem services. In addition to wetlands losses, agricultural development also resulted in massive losses of prairies, forests, stream side vegetation, and other types of ecosystems important to **wildlife habitat** and biodiversity. But agricultural lands are essential to remaining species that find habitat in agroecosystems. Some species depend on the natural areas within agricultural landscapes, while others have adapted to croplands and pasturelands. Restoration and protection of habitat on agricultural lands is a target of federal conservation policies administered by USDA and other federal agencies, and of conservation policies conducted by state resource conservation agencies and local governments (McElfish, 2007). Threats to endangered species resulting from pesticide use are a concern of the USEPA.

Preserving **agricultural landscapes**, especially on the periphery of urban areas is a major agri-environmental goal for state and local governments, with programmes existing in all states, and also a target of USDA programmes. The conversion of agricultural land to developed uses with urban expansion was long framed as a concern for the loss of agricultural production potential. However, the scope of benefits is now recognised to include the protection of various ecosystem services that are lost or degraded with conversion, and the loss agricultural landscape amenities (Duke and Aull-Hyde, 2002; Kline and Wichlens, 1996, 1998).

Air quality is not among the leading environmental concerns associated with US agriculture but still qualifies for inclusion as a targeted agri-environmental public good for federal and state governments. The principle air quality authorities and goals for the federal government are provided by the Clean Air Act (CAA). Under the CAA the USEPA is directed to set National Ambient Air Quality Standards (NAAQS) for outdoor air. The standards cover six criteria pollutants and consist of primary (human health-based) and secondary (welfare-based) standards. State and local governments in areas that fail to meet the standards are required to develop State Implementation Plans that outline the measures they will implement to reduce the pollution levels and attain the standards. Farming and livestock practices contribute to particulate matter emissions in nonattainment areas and thus are of concern for meeting the standards. Agriculture's particulate emissions have not been regulated under the CAA, but are a matter of interest and policy development (CRS, 2013). For example, in response to federal ozone and particulate standards, the state of California is now requiring farmers in the San Joaquin Valley to develop management plans for reducing dust, imposed restrictions on the burning of crop residues, and requires large dairies to reduce ammonia emissions. USDA administers no regulatory programmes intended to reduce dust and wind erosion, but does provide technical and financial assistance for practices that reduce dust and wind erosion. "Right to Farm" legislation in states has given farmers some protection against laws suit for local environmental nuisances like odours and flies, but the growth in livestock intensive production practices is prompting the development of new legal and regulatory tools for such agricultural disamenities by state and local governments (Kapplan, 2013). Greenhouse gas (GHG) emissions recently became a federal regulatory target with the decision by the USEPA to regulate these gases under authorities provided by the CAA. Some states are also developing laws and programmes for GHGs. Agriculture is not yet the target of programmes to limit GHG emissions programmes, but programmes that do are under consideration (CRS, 2013). Carbon sequestration is also of considerable policy interest but not yet an area of significant policy development (Lewandrowski et al., 2004).

Apart from air quality impacts of agriculture, air pollution is of concern in agriculture because of adverse impacts on agricultural productivity. The NAAQS secondary standards consider the impacts of air pollution on economic activity and costs. Impacts of air pollutants on agriculture are a consideration in the secondary standards.

3. The production of targeted agri-environmental public goods

The environmental consequences of agriculture are influenced by a variety of factors. One is the amount of agricultural activity that affects the environment, and one indicator of this scale is the amount land in agriculture. By this indicator, the United States, with more arable land than any other nation, should have a comparatively large agri-environmental public good foot print.

However, there is much more than the land area in agriculture that is important. Other factors include the characteristics of farming systems (e.g. tillage intensity, chemical use, nutrient management, animal intensity, crop diversity), characteristics of the soils, climate, and topography, the ecological structure of the agricultural landscape, and the types and sensitivity of the agricultural resources that are affected by agriculture (Swinton et al., 2007; Zhang et al., 2007). These factors are not independent, and in the very large and highly geologically, topographically, climatically, and ecologically diverse landscape of the United States, vary greatly across space. One indicator of this diversity is the number of distinct ecoregions mapped by the USEPA that are used to structure and implement ecosystem management strategies across federal agencies, state agencies, and nongovernmental organizations (Omernik et al., 2000, McMahon et al., 2001). Factors determining ecoregions include geology, topography climate, hydrology, vegetation terrestrial and aquatic fauna, and soils. At the third coarsest classification level, the coterminous 48 states of the United States (excludes Alaska and Hawaii) is subdivided into 86 distinct ecoregions. These comparatively large regions are subdivided into a substantially larger number of ecoregions that are more homogeneous but still large enough to be useful for management agencies. Another indicator of diversity more specific to agriculture is the USDA subdivision of the United States and its territories into 278 major land resource areas (MLRAs) for interstate, regional, and national planning (NRCS, 2006). MLRAs are large land areas that are composed of many geographically associated land resource units (LRUs). LRUs may contain thousands of hectares of land sharing similar topography, other landscape features, and resource uses and concerns.

Cropland is found throughout the nation, but concentrated in the humid and fertile central regions of the conterminous 48 United States. In 2007, the USDA defined Corn Belt (Illinois, Indiana, Iowa, Missouri, Ohio), and Northern Plains (Kansas, Nebraska, North Dakota, South Dakota) production regions contained nearly 50% of the cropland in the contiguous 48 states, and cropland accounted for more than 50% of the land use in these regions (Nickerson et al., 2011). Grazing is also distributed throughout the nation, but concentrated in the arid west, which is less suited to crop production but can support extensive grazing uses. In 2007, the USDA defined Mountain (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming) and Southern Plans (Oklahoma, Texas) production regions contained nearly 70% of the grassland pasture and range land in the coterminous 48 states, and these lands accounted for more than 55% of the land use in these regions (Nickerson et al., 2007). However, inventories of cattle, hogs and pigs, poultry and other livestock are often higher in crop production regions with intensive animal feeding operations than in regions with lower intensity grazing (NRCS, 2007). This can be important for water quality impacts resulting nutrient runoff from chemical fertilisers applied to fields for feed grain production, and from land application of animal manure. Forest-use land is most prevalent in the eastern states, accounting for 55% or more of the land in the USDA defined production regions east of the Mississippi excluding the Corn Belt (Wickerson et al., 2007).

Within these broad categories, there are significant variations in the dominant commodities, farm size, production systems, and resource use within and across regions, again reflecting variations in soils, climate, topography, and location relative to markets and transportation systems (e.g. Sommer and Hines, 1991). The diversity of farming activities combined with diversity of ecosystems in which they occur, results in a significant diversity of agri-environmental outcomes and issues.

4. The status of targeted agri-environmental public goods

A comprehensive assessment of the status of agri-environmental public goods provision across the United States does not exist. Ideally, such an assessment would quantify environmental conditions (e.g. water quality, air quality, biodiversity) affected by agriculture, and since agriculture is generally one of several drivers of any particular environmental outcome, attribute the degree to which agriculture is responsible for the condition. To produce such an assessment would be a monumental task given the complexity of the environmental public goods, the heterogeneity of relationships between agriculture and the environment across US agro-ecosystems, the small spatial scales relevant to the production and management of most agri-environmental public goods, the inability to measure environmental flows from farms routinely at acceptable cost, and limited understanding of ecological relationships needed to assess agriculture's contributions to specific goods in specific places of varying spatial scale. There are, however, various assessments that are indicative of progress, problems, and opportunities.

Interest in agri-environmental public goods had led to the development and reporting of related indicators. For example, USDA provides periodic reports tracking farm numbers and size, major land uses, productivity growth, biotechnology use, pest management, nutrient management, water management and conservation, soil management and conservation, organic farming systems, and conservation spending (Osteen et al., 2012). This indictor set is largely composed of *pressure indicators* rather than *condition indicators* reported at high levels of spatial aggregation. Another source of indicators is the OECD Environmental Data Set and Agri-Environmental Indicators OECD, 2013b). These are also largely pressure indicators though there are some condition indicators. It is, however, implemented at a high level of spatial aggregation. The USEPA and other US agencies collect data on water quality conditions, air quality conditions, and ecological conditions at various levels of spatial resolution, and with varying capacity to support statistically valid inferences about environmental conditions (USEPA, 2008). The environmental conditions indicated by such data sets are generally determined by multiple drivers and do not therefore directly indicate the role of agriculture. Table 3 summarises examples of pressure and condition indicators used for the status of agri-environmental public goods in the United States.

Table 3. Examples of indicators of agri-environmental public goods targeted in the United States

Agri-environmental public goods	Pressure Indicators	Condition Indicators	Selected observations
Soil Quality	• Areas of land with high water or wind erosion risks in production. • Areas of land treated with soil conservation and soil improvement practices. • Spending on soil conservation and improvement practices.	• Organic matter, and indicators of the physical (e.g. structure, depth, infiltration and bulk density, water holding capacity), chemical (e.g. pH; electrical conductivity; extractable N-P-K), and biological (microbial biomass C and N; potentially mineralizable N; soil respiration) characteristics.	• US soils and their basic properties are extensively mapped. • *Ad hoc* soil surveys are conducted for general farm, local, and wider area planning, but comprehensive indicators of trends in national soil quality are not available. • Use of conservation tillage practices has increased steadily since 2000 in major crops. Impacts of changes in crop rotations and land in crops have mixed effects on erosion (Ebel, 2012). • 11.7 million hectares of environmentally fragile land were enrolled in land retirement programmes in 2012 (Hellerstein, 2012). • USDA conservation programmes provide significant technical and financial support for soil protection. Overall spending has increasing steadily since mid-1980s (Classen, 2012).
Water Quality	• Area of land with high water erosion risks in crop production. • Area of working lands treated with water quality protection practices (e.g. nutrient management, soil and water conservation). • Pesticide applications. • Nitrogen and phosphorous applications. • Animal densities and types. • Spending on soil conservation and improvement practices. • Estimated pollution loads from agriculture (the nonpoint character of agricultural pollution makes metering pollution from individual farms impractical).	• Pollution concentrations in agriculturally influenced ground and surface waters. • Physical, chemical, and biological conditions in agriculturally influence waters. • Qualitative assessments of water quality conditions and sources. • Water bodies designated as agriculturally impaired under provisions of the CWA (303d assessments).	• Comments above regarding soil quality indicators related to erosion apply to water quality since runoff and sediment are major water quality issues. • Quantities of pesticide active ingredients declined 1.4%, respectively per year during 1996-2007, but increased from 2006 to 2007; herbicide use increased (Livingston and Osteen 2012). • Commercial fertiliser consumption fell from 23 million short tons in 2004 to 21 million short tons in 2010, with high fertiliser prices contributing to the decline. Since 2004, nitrogen recovery rates (amount removed by harvested crop/amount applied) on corn and cotton have increased, and the shares of planted acreage where application rates exceed 125% of the crop's agronomic need have decreased. Phosphate recovery rates are relatively unchanged for corn and cotton. Mining phosphate in soybean plantings increased (Huang and Beckerman, 2012). • Onfarm irrigation efficiency has increased (Schaible and Aillery, 2012). • Agriculture is the leading contributor to water quality impairments, degrading 60% of the impaired river miles and half of the impaired lake acreage surveyed by states, territories, and tribes. The most common nonpoint pollutants are sediments and nutrients. Other pollutants are pesticides, pathogens, salts, and heavy metals (USEPA, 2009).

Agri-environmental public goods	Pressure Indicators	Condition Indicators	Selected observations
Water quantity	• Intensity of water uses relative to supplies • Irrigated land areas	• Frequency, duration and extent of water shortages	• Approximate 7.5% of United States cropland and pasture-land was irrigated in 2007. Nearly 75% of the irrigation is found in the 17 Western States (Schaibel and Aillery, 2012) • Irrigated agricultural land area increased by nearly ½ million hectares, with Nebraska accounting for most of the increase (Schaible and Aillery, 2012) • Agricultural irrigation has continued to expand in the humid Eastern United States (Schaible and Aillery, 2012) • Irrigated agriculture accounted for 37% of freshwater withdrawals in 2005, and 80-90% of consumptive water use (Kenny et. al., 2009) • Between 1950 and 2005, freshwater withdrawals for all uses increased by 128% (Kenny et al., 2009). • Water conserving irrigation technologies are being adopted, but more than half of irrigated cropland acres in the West are irrigated with more traditional, less efficient application systems (Shaible and Aillery, 2012)
Wetlands and wildlife habitats	• Area of wetlands and other habitats converted to agricultural uses. • Area of habitats provided by agricultural lands converted to nonagricultural uses. • Area of agricultural land managed to restore and protect wildlife. • Applications of pesticides harmful to wildlife.	• Area and distribution of habitat types found on agricultural lands. • Ecological connectivity. • Benthic macroinvertebrates in wadeable streams. • Bird populations. • Fish populations. • Submerged aquatic vegetation.	• Total wetland acreage declined over the last 50 years, but the rate of loss appears to have slowed over time. Development of land for non-agricultural uses (e.g. urban development) has replaced agriculture as the key pressure on wetlands area. Wetland creation on agricultural land between 1998 and 2004 more than offset wetlands losses from non-agricultural land development (USEPA, 2008). • Bird populations show a net decline of observed populations most commonly found in grasslands and shrublands, comparable increases and decreases in observed populations in woodlands, and some gains in observed populations inhabiting urban and water/wetlands areas (USEPA, 2008). • Comparisons between current and historical fish species compositions indicate that one-fifth of the watersheds of the contiguous 48 states retain their full complement of fish species, while about a quarter have experienced a loss in species of 10% or more (USEPA, 2008).

Agri-environmental public goods	Pressure Indicators	Condition Indicators	Selected observations
Agricultural landscapes	• Conversion of agricultural lands to other uses, principally urban development. • Spending on farmland protection programs.	• Farmland areas providing amenity services to neighbouring urban populations.	• Loss of cropland to development between in 1982 and 2007 was 445.2 million hectares (USDA, NRCS, 2007).
Air Quality	• Areas of land burned. • Livestock densities. • Estimated emissions of particulates, greenhouse gases, and other pollutants (air emissions from agriculture are diffuse and often impractical to meter).	• Concentrations of regulated (criteria) pollutants.	• Agriculture generally has not been considered a significant cause of air quality problems or greenhouse gas emissions, and has not been regulated as an air pollution source. However, the growth of concentrated animal operations is leading to new assessments of agriculture and air quality (Aillery et al., 2005). In particular, concentrated animal operations are the leading source of ammonia emissions in the United States (Abt Associates, 2000; Aillery et al., 2005). • Ambient concentrations of criteria pollutants aggregated across monitoring stations decreased between 1990 and 2002 (USEPA, 2008).

4.1. Soil quality

US soils and their basic properties are extensively mapped. Soil surveys are conducted for general farm, local, and wider area planning. However, due to the size and heterogeneity of the United States, comprehensive indicators of soil quality trends are not available. Nationwide, the most pervasive cause of agricultural soil quality degradation is soil erosion. The use of conservation tillage practices has increased steadily since 2000 in major crops. As of June 2012, 11.7 million hectares of environmentally fragile land had been enrolled in land retirement programmes and converted to vegetative covers that reduce erosion risk (Hellerstein, 2012). Irrigation-induced salinization is a significant cause of soil degradation in some areas in the Western US. At least half of US irrigated cropland acreage is still irrigated with less efficient, traditional irrigation application systems (Schaible and Aillery, 2012a).

4.2. Water quality

As noted above, the USEPA and other US agencies, and state water quality authorities collect various types of data on water quality with varying capacity to support statistically valid inferences about water quality conditions and their causes. There are also numerous studies exploring the role of agriculture in water quality problem in various watersheds. For regulatory purposes, a key activity is the periodic water quality assessments required of states under Section 303(d) of the CWA to determine whether waters within their jurisdictions meet water quality standards. The states are required to develop TMDLs for those that do not. The most recent *National Water Quality Inventory* (USEPA 2009) indicates that agriculture is the leading contributor to water quality impairments, degrading 60% of the impaired river miles and half of the impaired lake acreage surveyed by states, territories, and tribes. The most common nonpoint pollutants are sediments and nutrients. Other pollutants are pesticides, pathogens, salts, and heavy metals.

Negative water quality impacts of agriculture are a pervasive issue in regions with intensive crop and livestock production (Shortle et al., 2012). Rainfall and snowmelt runoff from croplands carry nutrients applied to fields in chemical fertilisers and animal manures, pesticides, sediment from eroded soils into streams, lakes, estuaries, and coastal waters. Runoff from barnyards and feedlots, and direct discharges of wastes, into surfaces waters carry nutrients and pathogens. Nutrient pollution from nitrogen and phosphorous applied to land in chemical fertilisers or in manures, and sediments, is a major national concern (State-EPA, 2009; Diaz and Rosenberg, 2008; Howarth, 2008). This is due to pervasive aquatic ecosystem damages from over-enrichment of fresh, estuarine, and coastal waters (particularly along the Atlantic and Gulf coasts), and the major resources impacted. Significant examples are the Chesapeake Bay, the largest and most productive estuary in the United States, and the Gulf of Mexico, also a leading US fishery. Crop and animal feeding operations in the Chesapeake Bay watershed are a leading source of nutrients and sediments that have degraded living resources of this estuary (State-EPA, 2009). The *dead zone* at the mouth of the Mississippi River in the Gulf of Mexico is in large part a consequence of nutrients and sediments from agricultural production in the humid and fertile central region of the United States (State-EPA, 2009). Human health risk from contamination of drinking water by nitrates and pesticides entering ground water supplies is a significant concern in some regions (Esser et al., 2002, Nolan et al., 1998). Endocrine-disrupters in water from pharmaceuticals used in animal enterprises are an emerging concern for impacts on the safety of drinking water for humans, and impacts on aquatic species (USEPA 2013a). Irrigated agriculture in the Western states causes nutrient and other pollution problems found in other regions, but due to the nature of the soils in irrigated regions, irrigation return flows can be a source of salts and heavy metals that can contaminate water (USEPA, 2013b). Harm to bird populations from selenium poisoning in California's Kesterson National Wildlife Refuge is a major example. The refuge is a wetland created from irrigation return flows.

Pollution loads are substantially determined by production practices, locations, and concentrations, and can be reduced through changes in farming practices. For example, soil erosion leading to sediment loads depends on the slopes and erosivity of farm fields, the degree to which tillage practices and crop types and rotations leave soils susceptible to erosion, and the implementation of conservation practices that filter sediment from runoff. Nutrient loads from cropland are affected by nutrient inputs, nutrient uptake in crops, and conservation practices intended to reduce runoff and filter nutrients from runoff. In areas with high livestock concentrations, nutrient applications to soils can be driven by animal waste disposal more than by crop fertility management, resulting in large nutrient surpluses and nutrient pollution. Technologies to reduce the imbalance and environmental impacts involve feed management to minimise animal nutrient inputs and increase animal nutrient uptake to reduce nutrients in manure, and various manure storage, treatment, and application methods. Pollution harms depend on the environmental susceptibility of regions in which agriculture occurs. For example, the Mid-Atlantic is a water rich environment with nutrient-sensitive aquatic ecosystems, resulting in vulnerability to the nutrient intensive crop and animal-feeding agriculture conducted in that region.

Water quality impacts of agriculture are not entirely due to pollutants moving from agricultural land into water resources. Agricultural activities have transformed riparian zones, stream forms, and other landscape features that affect water quality and aquatic ecosystems. This has led to widespread interest in initiatives to restore and better manage riparian zones in agricultural (and other) areas to remove nutrients and sediments before runoff reaches streams and lakes. The benefits include not only water quality protection, but other environmental benefits associated with the restoration of habitats for beneficial insects and birds. The same is true for restoration of wetlands that were converted to crop production.

4.3. Water quantity

Water quantity issues in agriculture are related to irrigation. These issues include irrigation efficiency, surface and groundwater availability for irrigation, and conflicts over water for other uses, including endangered species. Irrigated agriculture is significant part of the agricultural production in the United States. In 2007, about 7.5% of United States cropland and pasture-land, was irrigated, but irrigated farms accounted for 55% of the total value of crop sales while also supporting the livestock and poultry sectors through irrigated production of animal forage and feed crops (Schaible and Aillery, 2012a). Nearly 75% of the irrigation is found in 17 Western States (Washington, Oregon, California, Idaho, Nevada, Arizona, Montana, Wyoming, Colorado, Utah, New Mexico, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas)(Schaibel and Aillery, 2012). The United States Geological Survey estimates that irrigated agriculture accounted for 37% of freshwater withdrawals in 2005, and 80-90% of consumptive water use (Kenny et al., 2009). Between 1950 and 2005, freshwater withdrawals for all uses increased by 128% (Kenny et al., 2009). Agriculture and energy accounted for most of this increase.

While climate change poses long term risks to water availability, the major contemporary challenge to agricultural water availability is competition from alternative uses, particularly in the Western States where surface-water systems are over-appropriated and groundwater aquifer levels are generally declining (Schaible and Aillery, 2012b). While population and economic growth increase water demand for many non-agricultural water uses, Native American water rights claims, expansion of the energy sector, and environmental flow requirements are the most important emerging or expected sources of increased demand intensifying water use conflicts (Schaible and Aillery, 2012b). A series of federal court decisions since 1908 have established and expanded Native American reservation rights to water. Resulting claims for many reservations are under negotiation or remain unresolved within settlement disputes or judicial proceedings, but resolution of these claims are expected to affect the water available for competing uses, including off-reservation irrigated agriculture (Schaible and Aillery, 2012b). Environmental flows refer to water flows needed to provide multiple benefits adversely affected by low water flows. These include dilution of sewage and other effluents, fish and wildlife habitat, water-based recreation and aesthetics, hydropower, navigation, groundwater recharge, riparian wetlands, and migratory bird habitat. Traditional water management in the United States served off-stream uses, but beginning in the 1970s federal and state water management laws, institutions, and policies began to recognise the value and to protect environmental flows. Environmental flow protections have led to reallocation of water from agriculture in Western states, and represent an increasingly important conflict with agriculture's access to water (Schaible and Aillery, 2012b). Energy sector growth, for production of biofuels and other energy sources, is placing increasing demand on water resources, that could affect irrigated in the water-scarce Western States (Schailbe and Aillery, 2012b).

Adoption of water-conserving irrigation technologies can help alleviate harm to agriculture from increasing water scarcity. Technological innovation and investments in irrigation systems have been increasing the efficiency of irrigated agriculture over the past several decades, but significant potential exists for improvement through used of advance irrigation systems and water management practices (Schaible and Aillery, 2012b).

4.4. Wetlands and wildlife

Agriculture has historically had a negative impact on **wetlands** and **wildlife** primarily through the conversion of wetland, grasslands, and other ecosystems to agricultural production**.** Farming practices, including the timing and types of pesticides use, crop rotations, and the timing of harvesting and other field operations, can also impact wildlife for better or worse. Aquatic species are harmed by water pollution and by adverse effect of changes in stream flow regimes, sediment, and removal of riparian vegetation on water flows, temperatures, and aquatic habitat. While overall agricultural land use is in secular decline, significant annual changes within agricultural land use types occur between cultivated and uncultivated uses. Impacts of these shifts are a significant concern for wildlife habitat. For example, Lubowski et al. found that watersheds with high counts of imperiled birds coincide with areas experiencing changes in the extensive margin of cropland in the Northern Great Plains and Prairie Gateway. They also found that areas where high levels of cultivated cropland changes overlap with imperiled fish/mollusks are the Central Valley of California, areas along major rivers, and some parts of the Southern Seaboard**.** Wildlife that is supported on agricultural lands is threatened by conversion of farmland to urban uses.

The USEPA's 2008 Report on the Environment (ROE) is the most extensive effort to date to explore trends in environmental conditions using a large suite of environmental indicators in the United States (USEPA, 2008). The report finds that total wetland acreage declined over the last 50 years, but the rate of loss appears to have slowed over time. The report suggests that the pressures of urban development, rural development, silviculture, and conversion to deepwater (e.g. the disappearance of coastal wetlands or flooding to create reservoirs) have replaced agriculture as the key pressures on wetlands area. These development activities contributed to losses in wetland acreage between 1998 and 2004, but that loss was more than offset due largely to wetland creation and restoration on agricultural lands, and on lands that includes conservation lands, areas in transition from one land use to another, and other lands that do not fall into the major land use categories.

With regard to the extent of ecosystems, at a national scale the ROE finds that over the last three decades, crop and farm acreages have decreased, timberland (productive forest land) has remained fairly constant, and developed lands have increased. Within the larger-scale trends, as there are within agricultural land uses, there are subtle shifts at smaller scales that can have ecological significance. As with wetlands, the ROE suggests that development is increasingly important compared to agriculture as a threat to ecosystems. The ROE concludes that the growth in developed land uses reflects in part the increases in human populations, but also reflects an increase in the amount of land used per person. The increase in developed land was almost two times the increase in population from 1982 to 2003. Like agriculture, the impact of development is more than a shift in the extent and distribution of ecological systems. For example, development affects the volume, timing, temperature, and chemical composition of runoff affecting surface water quality and aquatic ecosystems (USEPA, 2008).

National indicators on biodiversity are limited. Indicators for birds used in the ROE show a net decline of observed populations most commonly found in grasslands and shrublands, comparable increases and decreases in observed populations in woodlands, and some gains in observed populations inhabiting urban and water/wetlands areas. Comparisons between current and historical fish species compositions indicate that one-fifth of the watersheds of the coterminous 48 states retain their full complement of fish species, while about a quarter have experienced a loss in species of 10% or more. Absolute losses have occurred primarily in the Midwest and the Great Lakes, while on a percentage basis; losses have been highest in the Great Lakes and the Southwest. The greatest diversity of fish species is found in the Southeast. The greatest reduction in numbers has occurred in portions of the Midwest and the Great Lakes, where several watersheds have lost more than 20 species. Southwestern watersheds have all lost fewer species, but because these watersheds historically supported fewer species, on a percentage basis their fish faunas are regarded as less intact.

4.5. Agricultural landscapes

National land use data discussed above indicate a secular decline in agricultural land, with conversion to urban development being a significant driver. The recent report for the UDSA Natural Resource Inventory surveying agricultural resources estimates that loss of cropland to development between the inception of the survey in 1982 and 2007 was 11 million acres (USDA, NRCS, 2007). The losses for the last five, five-year reporting periods are 1.75 million acres (1982-87), 1.9 million (1987-92), 2.8 million (1992-97), 2.0 million (1997-2002) and 1.65 million (2002-07).

4.6. Air quality

Agricultural activities can result in a variety of air pollutants. Winds can erode soils and create dust problems. Dusts also result from field operations. Nitrogen applied to fields can volatilise and enter that air in gaseous forms. Winds can cause sprayed pesticides to drift. Livestock production releases hydrogen sulfide, ammonia, methane, volatile organic compounds, and odours. Particulates and nitrogen oxides are emitted from diesel and gas powered equipment, and from fields cleared of unwanted vegetative material by burning. These pollutants may affect people's health, ecosystems, reduce visibility, create nuisances, and contribute to global warming.

As with water quality protection, the air quality impacts of agriculture can be improved through various practices. An important issue in this regard is that environmental flows from agriculture to different media are connected. An example is nitrogen emissions. Measures to reduce nitrogen discharges to water from an animal feeding operation could increase emissions to air and vice versa unless the two flows are addressed simultaneously (Aillery et al., 2005).

Agriculture generally has not been considered a significant cause of air quality problems or greenhouse gas emissions, and has not been regulated as an air pollution source. However, the growth of concentrated animal operations is leading to new assessments of agriculture and air quality (Aillery et al., 2005). In particular, concentrated animal operations are the leading source of ammonia emissions in the United States (Abt Associates, 2000; Aillery et al., 2005).

The ROE finds that air emissions and monitored ambient concentrations aggregated across monitoring stations of every criteria pollutant (or the corresponding precursors) decreased between 1990 and 2002—the period of record covered by the National Emissions Inventory. The ambient air monitoring system measures ambient levels primarily in urban and suburban areas and nationwide trends in aggregate monitoring data may not reflect air quality trends at finer scales or for different subsets of monitoring stations (USEPA, 2008). Further, while ROE indicators provide fairly complete information on outdoor air quality trends, they are less useful for assessing the associated health and environmental effects (USEPA, 2008).

5. Policy measures and the efficiency of agri-environmental public goods provision

The direction of agricultures' influence on specific environmental conditions in specific locations depends on the alternatives under consideration. For example, some agricultural practices are more harmful to air or water quality, biodiversity, or global climate than others. In consequence, *changes in agricultural practices* can increase or decrease the supply of environmental public goods. An alternative comparison is between agricultural and non-agricultural land uses. Agriculture is generally ecologically disruptive compared to forests or native landscapes. However, urban land uses generally pose a far greater risk to air and water quality, and ecosystem services generally, than agricultural production in the same location. Accordingly, agricultural land use can be viewed as supplying environmental public goods when compared to some alternatives, and the opposite when compared to others. These distinctions are important when considering US laws, policies, and programmes for agri-environmental public goods. Some are intended to increase the supply of such goods by encouraging, or mandating, practices that are less harmful to the environment (or more efficient in using water resources) than current practices. Others are intended to increase the supply of such goods by converting environmentally sensitive agricultural lands to permanent vegetative covers. Conversely, a third approach is to discourage agricultural development of highly erosive lands or wetlands. And a fourth approach is intended to prevent or limit the conversion of agricultural land to more developed uses. All four approaches are implemented to varying degree by federal, state, and local governments as part of laws, policies, and programmes for environmental protection and resources conservation. Tables 4 sand 5 summarise these four approaches and corresponding programmes for agri-environmental public goods.

This review of policy measures combines those for soil quality, water quantity, wetlands, wildlife and air quality. This is because the major programmes for these agri-environmental public goods are USDA programmes that are intended to serve multiple objectives. These objectives include water quality, but there are several dimensions of water quality that warrant separate treatment. These include the dominance of water quality as an agri-environmental policy concern, the significant role of the states in managing agricultural nonpoint pollution under the CWA, and the potential under TMDLs to assign pollution reductions to agriculture. Conservation of agricultural landscapes is supported to some degree by USDA conservation programmes but this agri-environmental public good is primarily addressed through state and local policy measures.

Table 4. Four Approaches to agri-environmental public goods in the United States

Approaches	Programmes (related agri-environmental public goods)
1.Encouraging (or mandating) pro-environmental farming practices on working lands	• Federal and state education, and technical and financial assistance programmes for conservation and water quality practices on working lands programmes (soil quality, water quantity and quality, wetlands and wildlife, air quality) (e.g. USDA EQIP, CSP) • Federal and state programs education, technical and financial assistance, and regulatory programmes for pesticides and integrated pest management (water quality, wetlands, wildlife, air quality) • Federal and state concentrated animal feeding operation regulations (water quality) • State nutrient trading programmes (water quality) • State tax incentives (water quality)
2.Converting environmentally sensitive agricultural lands to permanent vegetative covers	• USDA Land Retirement Programmes (water quality, wetlands and wildlife, air quality) (USDA CRP) • Mitigation banking (wetlands and wildlife)
3. Discouraging conversion of environmentally sensitive lands to agriculturally productive uses	• USDA Sodbuster (soil quality, water quality, wildlife, air quality) • USDA Swampbuster (wetlands, wildlife)
4. Preventing or limiting the conversion of agricultural land to more developed uses	• USDA agricultural land preservation programmes (agricultural landscapes) (USDAACEP) • State and local preservation programmes (agricultural landscapes) • Right to Farm (agricultural landscapes)

Table 5. Agri-environmental Policy Measures in the United States

Instruments	Targeted Agri-environmental Public Goods						
	Soil quality	**Water quality**	**Water quantity**	**Wetlands**	**Wildlife**	**Air quality**	**Agricultural landscapes preservation**
Regulatory requirements		-Pesticides (federal); -Regulated concentrated animal feeding operations (federal and state); -Farming practices (e.g. nutrient management) (some states)	-Laws and regula-tions governing access to water, and water use vary across and within states	-Federal and state laws governing wetland draining and filling	-Federal and state laws protection for endangered species habitat	-Emissions of criteria pollutants (California)	-State and local land use zoning
Environmental taxes/charges		-Agricultural privilege tax (Florida)	-Water pricing				
Environmental cross-compliance	-USDA Highly Erodible Land and Wetlands Conservation (Sodbuster)			-USDA Highly Erodible Lands and Wetlands (Swampbuster)	-USDA Crop Production on Native Sod (sodsaver) Some states		-USDA Crop Production on Native Sod (sodsaver) Some states
Payments based on farming practices	-USDA EQIP -Some states	-USDA EQIP -Some states	-USDA EQIP		-USDA EQIP	-USDA EQIP	
Payments based on agricultural land retirement	-USDA Land Retirement Programs (CRP)	-USDA Land Retirement Programs (CRP)	-USDA Land Retiremen t Programs (CREP) in some states	-USDA Land Retirement Programs (CRP/CREP/AC EP)	-USDA Land Retirement Programs (CRP/ CREP)	-USDA Land Retirement Programs (CRP)	
Payments based on performance rankings	-USDA Conservation Stewardship Program (CSP)	-USDA (CSP)	-USDA (CSP)	-USDA (CSP)	-USDA (CSP)	-USDA (CSP)	
Tradable rights/permits		-Water quality trading (some states)	-Water Markets	-Wetlands Mitigation Banking	- Conservation Mitigation Banking		
Right to Farm							All states
Conservation Easements/Purchase of Development Rights/Preferential treatment of agricultural land in property taxation							-USDA conservation easements (ACEP); state and local preservation programs
Facilitative	Various federal, state and local educational programs, federal and state technical assistance programs, federal organic labelling requirements						

* This table is intended to capture major policy measures that are actively used for targeted agri-environmental public goods in the United States.

**This table is adapted from Ribaudo, M. (2013), *Policy Instruments for Protecting Environmental Quality*. www.ers.usda.gov/topics/natural-resources-environment/environmental-quality/policy-instruments-for-protecting-environmental-quality.aspx#.Uh4f_j_leg0. Accessed 28/8/2013.

5.1. Water quality

Market failure

Water pollution is a classic case of market failure resulting in an environmental externality. Water quality is harmed by polluting discharges. It is non-rival, but can be exclusive (regulated access) or non-exclusive (open access) depending on situations. Historically, polluters were not required to have property rights to pollute, so that water was an open access good for pollution. The result was serious degradation of water resources. The 1972 Clean Water Act (CWA) created a new paradigm for water quality management. With this paradigm the United States essentially nationalised access to surface waters for point sources of pollution, requiring polluters to acquire discharge permits in order to have access to water for discharging waste water. Conventional point source emissions are amenable to regulation through discharge permits because discharge points can be identified and metered. This is the not the case with nonpoint sources because nonpoint pollutants reach receiving waters by complex diffuse pathways that make metering of individual nonpoint source contributions infeasible or impractical. Land use controls, a traditional purview of the states, were recognised as the key to nonpoint pollution management and thus nonpoint control was delegated to the states with the expectation that their actions would lead to the achievement of water quality goals.

Federal regulation of agricultural point sources

The 1972 CWA and subsequent amendments define the regulatory framework for surface water pollution control in the United States. The principle mechanism for water quality protection under the CWA is the National Pollution Discharge Permit System (NPDES) which requires point sources of water pollution to obtain NPDES discharge permits in order to be allowed to discharge pollutants. The permits require compliance with national effluent standards established by the USEPA. While the NPDES mechanism is largely a programme for regulating industrial and municipal dischargers, NPDES permits are also required for large Concentrated Animal Feeding Operations (CAFO) that discharge into stream. While CAFOs can be significant local sources of surface water pollutants, agricultural pollution loads are mostly of the nonpoint type. In consequence, the NPDES system is largely inapplicable to agriculture.

State regulation of agricultural nonpoint sources

Under the CWA, authority for nonpoint pollution control is delegated to the states and authorised tribes. State laws governing agricultural nonpoint pollution are highly varied. Nearly all states have some general statutory authority to deal with nonpoint source discharges that can be shown to result in water pollution, but agriculture is often exempted (ELI, 1997). States that provide legislative authority for agricultural nonpoint regulation as part of generally applicable pollution control authorities do not apply these authorities to agriculture but instead defer to other approaches. Concentrated animal feeding operations are the most common target of state regulations. Other types of regulations found in states include enforceable sediment controls, often administered by local governments or soil and water conservation districts, "accepted agricultural practice" requirements, and nutrient management requirements (ELI, 1997). When in place, such regulations may not apply to all farms but subsets of farm types, such as high-density animal operations, and enforcement actions may require a trigger such as a citizen law suit (Ribaudo, 2009). Indirect regulatory inducements are found is some states. Examples of this approach are exempting farms from water pollution enforcement actions, when such authorities exist, if they have adopted Best Management Practices (BMPs) (called a "safe harbor"), or exempting them from nuisance law suits if BMPs have been installed.

The dominant approach to state management of agricultural nonpoint pollution in practice is not regulatory, but is instead the application of voluntary compliance mechanisms that encourage the adoption of agricultural pollution control practices (referred to as BMPs) through education, technical assistance, and financial support through cost-sharing subsidies for the adoption of BMPs (See Table 5) (Ribaudo, 2009; ELI, 1997). An area of innovation in the use of incentives by states authorities is the development of pollution trading programmes that enable industrial and municipal polluters to meet their NPDES permit requirements through the purchase of pollution reduction credits from agriculture. Most address nutrients, with the most significant examples found in Pennsylvania and Ohio (Shortle, 2012, 2013).

Another interesting innovation in the use of incentives is an "agricultural privilege tax" imposed on cropland to fund pollution control initiatives in the Everglades Agricultural district (Shortle and Braden, 2013). Reductions in phosphorus discharges below a 25% reduction goal for the basin would result in collective credits (i.e. reductions in the tax rate) against the privilege tax. The programme also provides credits to individual farmers based on farm-specific performance.

Federal policies for agricultural nonpoint sources

While legal authority for agricultural nonpoint pollution resides with the states, the federal government has implemented significant programmes through USDA. These programmes are not regulatory, but offer technical and financial assistance to farmers for the adoption of BMPs. The CWA names the USDA as the primary federal source of financial and technical assistance to reduce agricultural non-point source pollution, and there has been a significant reorientation of USDA conservation programmes from their traditional mission of soil quality improvement, to the protection of water quality (Shortle et al., 2012). Currently, the USDA administers several programmes that provide farmers with financial assistance to adopt BMPs. The largest "working land" programme is the Environmental Quality Incentives Program (EQIP), which was established in 1996 to provide financial assistance in the form of cost-shares to producers to install and maintain conservation practices on eligible agricultural and forest land. Water quality is one of several EQIP objectives. The Agricultural Act of 2014 authorizes an increase in EQIP funding from USD 1.35 billion in 2014 to USD 1.75 billion in 2018. The Regional Conservation Partnership Program (RCPP) created by the Agricultural Act of 2014 consolidates functions of several preexisting regional programs: Agricultural Water Enhancement Program, Chesapeake Bay Watershed Program, Cooperative Conservation Partnership Initiative, and Great Lakes Basin Program. The RCPP is intended to coordinate conservation program assistance with partners to solve problems on a regional or watershed scales. RCPP assistance is provided through the Environmental Quality Incentives Program, Conservation Stewardship Program, Agricultural Conservation Easement Program, and Healthy Forests Reserve programmes.

Other USDA programmes that can have positive water quality impacts include the Conservation Reserve Program (CRP) and the Conservation Stewardship Program (CSP). The CRP was enacted in the mid-1980s and is the largest USDA agri-environmental programme in terms of budget. The programme solicits bids from farmers for converting cultivated land to grassland or forest. Bids are evaluated according to cost and a benefits index that ranks offers based on wildlife habitat benefits resulting from vegetative covers on contracted acreage, water quality benefits from reduced erosion, runoff and leaching, on-farm benefits from reduced erosion, and air quality benefits from reduced wind erosion. The Environmental Benefits Index used to assess environmental performance is not based on measured environmental outcomes or their economic values. Whereas EQIP is aimed at improving the environmental performance of working lands, including water quality provision from actively farmed land, the CRP is a land retirement programme (converting cropland to grassland or forest) that produces water quality and other environmental benefits by taking environmentally sensitive lands out of production. The authorizing legislation places a limit on the number of acres that can be enrolled. The limit was reduced from 38 million acres to 32 million acres by Food, Conservation, and Energy Act of 2008 (the 2008 Farm Bill), and is reduced again by 25% by the Agricultural Act of 2014.

The goal of the CSP is to encourage producers to address resource concerns in a comprehensive manner by (1) undertaking additional conservation activities, and (2) improving, maintaining, and managing existing conservation activities (Ribaudo, 2012). Unlike other USDA working lands programmes such as the EQIP that entail fixed practice-based payments, the CSP uses a points system to determine a conservation performance ranking that is used to select applicants and determine payment levels. It is important to note that the CSP performance assessment is not based on actual environmental outcomes or their economic values but on established scoring tables indicating the relative environmental benefit impact of different practices. Like the CRP, there is a limit on the number of acres that can be enrolled. This limit was also reduced by Agricultural Act of 2014.

Evaluation

The economic benefits of water pollution control in the United States have received significant attention from researchers. An extensive review is beyond the scope of the report, but a clear finding is that surface water quality is highly valued for recreational and aesthetic services, ecosystem services, and contributions to property values. A recent review of this literature is in Olmstead (2010). The costs of water pollution control have received attention and are also nontrivial, partly owing to the inefficiency of the uniform technology based effluent limits mandated by NPDES permits (Freeman, 2000). Economic assessments of the benefit and costs of water quality protection in the United States indicate that the incremental benefits of the CWA exceeded the incremental costs through the late 1980s, but not since (Olmstead, 2010). An important factor in this reversal is that water quality goals have been pursued through increasingly stringent and costly point source controls rather than through lower-cost agricultural nonpoint source controls. There is ample evidence that a better allocation of pollution control among and between point and agricultural nonpoint sources could pay large dividends in control cost savings (e.g. Shortle et al., 2012; USEPA, 2001). The implication is that from the perspective of economic efficiency, there is a misallocation of pollution control between point and nonpoint sources. Current interest in water pollution trading in the United States is prompted by expectations that nutrient credit trading between agricultural nonpoint sources and industrial and municipal point sources can improve the cost-effectiveness of pollution control (Shortle, 2012, 2013).

The misallocation of pollution control between agricultural nonpoint sources and industrial and municipal point sources is a consequence of policy choices and policy failures. The CWA provided powerful enforceable regulatory tools for point sources, but not for agricultural and other nonpoint sources. The voluntary compliance strategies that have been adopted for agriculture by the states have generally not provided the level of protection required to achieve mandated water quality goals (Ribaudo and Caswell, 1999; Ribaudo, 2009). As noted previously, agriculture is a leading cause of water quality impairments in the United States. USDA has devoted significant resources to technical assistance and financial for agricultural BMP installation practices over the years (more than USD 13 billion from EQIP alone since 2002 (Shortle et al., 2012)), but these too have been inadequate to meet water quality goals.

Recent assessments of the impacts of the water quality impacts of conservation practices in the Arkansas-Red, Upper Mississippi, Lower Mississippi, Missouri, and Ohio-Tennessee River Basins, the Chesapeake Bay Watershed, and the Great Lakes show that agricultural conservation practices have reduced nonpoint source loadings (NRCS, 2010, 2011a, 2011b, 2012a, 2012b, 2013a, 2013b). However, the same studies also conclude that significant amounts of cropland are still in need of improved nutrient and soil management for water quality protection.

The effectiveness and efficiency of existing USDA programmes is limited by the fact that they do not permit targeting resources to watersheds, or to producers within watersheds, so as to maximise the effectiveness of financial supports, and that they pay for installation of practices that farmers choose to implement, rather than for farmers' performance in achieving water quality improvements (Shortle et al., 2012). USDA programmes generally are *practice based*, not *performance based* (Shortle et al., 2012). Accordingly, while intended to produce water quality and other benefits, the policy targets of USDA conservation programmes are almost always conservation practices, not measurable agri-environmental outcomes. The CSP program is an exception in that participant selection and payment levels are based on an assessment of the relative performance of conservation activities. As noted above, the ineffectiveness of traditional agricultural policies has prompted some states to experiment with new performance-based approaches intended to improve the effectiveness and efficiency of water quality protection. These include water quality trading programs in several states, and Florida's performance-based agricultural privilege tax.

5.2. Soil quality, water quantity, wetlands, wildlife, and air quality

Market failure

Soil quality provides both private and public benefits. For farmers, the benefits of soil conservation practices are the returns from conservation of soil productivity. For a farmer-landowner, these returns would be realised in profits earned over time and in value of the land when sold (Miranowski and Hammes, 1984; Palmquist and Danielson, 1989). There are also significant off-farm benefits from soil conservation, largely resulting from avoided damages from sediments in streams, rivers, lakes, and estuaries (Hansen and Ribaudo, 2008). Similarly, water conservation practices on farms can provide private and public benefits. For farmers, efficient irrigation technologies and water conservation practices reduce expenditures on irrigation and improve profitability. Off farm environmental benefits would include reduced offsite water quantity impacts from irrigation return flows carrying farm chemicals, nutrients, and salts (Schaible and Aillery, 2012b). Further, given that the private cost of irrigation water to agriculture is often below the social costs, leading to inefficiently high use, social benefits result from reductions in water use and reallocation to higher valued uses (e.g. environmental flows) (Gollehon and Quinby, 2006).

Concern for soil quality after the Dust Bowl was the historical impetus for public programs intended to improve soil conservation practices. At the time, agriculture had undergone a major transformation with mechanization and other changes. The risks to soil productivity were not initially anticipated and the practices for protecting soils were not well known. Accordingly, a strong case could be made at the time for market failure in soil quality protection resulting from imperfect information about the private benefits of soil quality protection. This case has diminished with education and technical assistance. In contrast, the off-farm benefits of soil quality protection practices (e.g. erosion control) are distinctly public goods and thus inherently subject to market failure. Evidence of market failure is apparent in the significant costs of water quality degradation associated with sediment (Hansen and Ribaudo, 2008). Economic analysis in the 1980s indicated that offsite damage costs of soil erosion were a greater societal concern in the United States than onsite productivity costs, and to approach soil conservation as externality problem (Crosson, 1984; Ribaudo, 1986; Shortle and Miranowski, 1987).

The impacts of agricultural activities on the ecosystem services of wetlands and wildlife habitat are externalities. Evolving law and policy on wetlands has greatly diminished property rights allowing destruction of wetlands. Since the private benefits to farmers of wetlands is generally nil, activities that increase or enhance wetlands on agricultural land provide external public benefits that would not be provided by conventional markets. In contrast land use decisions that positively or negatively affect wildlife habitat other than wetlands are not so restricted. The improvement in wildlife populations that result from conversion of agricultural land to habitat, or management activities to protect and enhance wildlife provide external public benefits that would not be provided by conventional markets. Agricultural land is an essential target of policies to protect wildlife populations because of the crucial role of habitat to success for many species, and because of the large amount of land that is important to habitat being in agricultural private hands (Benson, 2001)

Federal policies

Soil quality has been a target of USDA conservation programmes since their inception in the 1930s. Protecting agricultural productivity and enhancing the vitality of the agricultural sector and farm dependent rural economies was the primary intent of these programmes at the outset. Water quantity was added with the significant development and use of irrigation in agriculture in the mid-1900s. Corresponding to new concerns for water quality and other agri-environmental public goods, a shift began in the 1990s to elevate objectives related to environmental externalities.

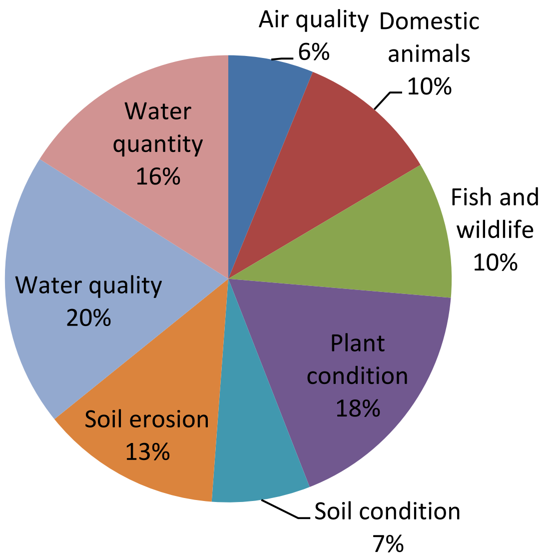
Presently USDA offers a suite of programmes to provide technical and financial support to farmers for adoption of various types of conservation practices addressing targeted agri-environmental public goods (Claassen, 2012). These programmes are voluntary and serve producers who seek assistance. *Land retirement programs* entail contracts with agricultural land owners that pay them to remove land from production for a period of 10 or more years and, in some cases, permanently. The land must be planted to buffers, grass or trees, or restored to wetland condition. The biggest land retirement programme is the Conservation Reserve Program (CRP). As noted above, the CRP awards contracts through a bidding process that takes into account cost and prospective environmental benefits. Prospective environmental benefits are evaluated using an index that consider wildlife habitat benefits resulting from vegetative covers on contracted acreage, water quality benefits from reduced erosion, runoff and leaching, on-farm benefits from reduced erosion, and air quality benefits from reduced wind erosion. An offshoot of the CRP program is the Conservation Reserve Enhancement Program (CREP), which targets high-priority conservation issues identified by local, state, or tribal governments or non-governmental organizations. In exchange for removing environmentally sensitive land from production and introducing conservation and introducing conservation practices, land owners are paid an annual rental rate. Unlike the CRP, CREP does not make use of a benefits index or competitive bidding. The contract period is typically 10-15 years, along with other federal and state incentives as applicable per each CREP agreement.

USDA's *working-lands programs* provide technical and financial assistance to farmers for installing or maintaining water conservation, nutrient management, and soil quality practices on producing lands. The major programmes are EQIP and the CSP (Claassen, 2012). The distribution of EQIP funds to agri-environmental targets by region in the period 2008-2010 are shown in Figures 3 and 4. The functions of EQIP have been expanded under the Agricultural Act of 2014 as a result of consolidation of program under the new law. EQIP incorporates the functions and funding of the repealed Wildlife Habitat Incentive Program.

Agricultural land preservation programs purchase development rights to maintain land in agricultural use. Newly created by the Agricultural Act of 2014, the Agricultural Conservation Easement Program (ACEP) provides funds for long-term easements for the restoration and protection of wetlands on farms, and for protection of agricultural land from conversion to nonagricultural uses. The ACEP consolidates the functions of the Wetlands Reserve Program, the Grassland Reserve Program (easement portion), and the Farmland Protection Program.

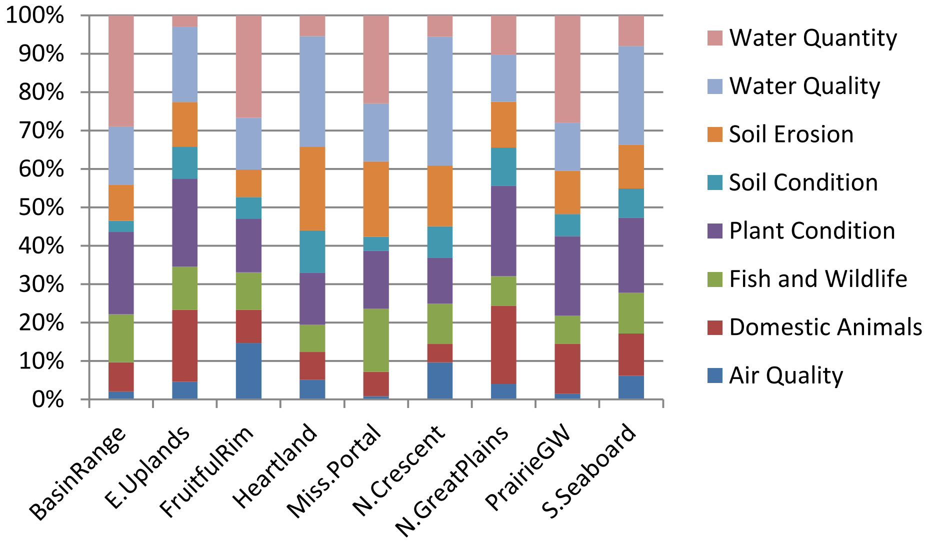
There are some exceptions to the voluntary nature of USDA conservation programmes. Under highly erodible land conservation provisions of federal agricultural legislation, farmers who crop on highly erodible land must implement an approved soil conservation system or risk losing eligibility for participation in USDA commodity, conservation, disaster payments, and with the Agricultural Act of 2014, subsidies for crop insurance premiums. These provisions were often referred to as "Sodbuster" for land not cropped before 1985 and "Conservation Compliance" for land cropped before 1985). Under wetland conservation provisions, (often referred to as "Swampbuster"), producers must refrain from draining wetlands or similarly lose eligibility for participation in other USDA programmes. The Agricultural Act of 2014 introduced "sodsaver" provisions to protect native prairie lands. The provisions reduce crop insurance premium subsidies and limit the yield or revenue guarantee available during the first 4 years of crop production on native sod for producers who till sod that had not been previously tilled. Some limitations would also apply to noninsured crop disaster assistance. Sodsaver applies only in Minnesota, Iowa, North Dakota, South Dakota, Montana, and Nebraska.

Figure 3. Distribution of EQIP contract obligations by resource concern, 2008-10



Source: Ribaudo, M. (2012). "Working Lands Conservation Programs". In Osteen, C., J. Gottlieb, and U Vasavada (Eds.), *Agricultural Resources and Environmental Indicators, 2012 Edition*. US Department of Agriculture, Economic Research Service, Economic Information Bulletin Number 98.

Figure 4. Distribution of EQIP contract obligations by resource concern and region, 2008-10



Source: Ribaudo, M. (2012). "Working Lands Conservation Programs". In Osteen, C., J. Gottlieb, and U Vasavada (Eds.), *Agricultural Resources and Environmental Indicators, 2012 Edition*. US Department of Agriculture, Economic Research Service, Economic Information Bulletin Number 98.

Non-USDA policies

While USDA programmes are the most important public policy mechanisms for soil quality, water quantity, wetlands, wildlife, and air quality from agriculture, there are a few others that are noteworthy. As noted above, the USDA collaborates with state-created

Soil and Water Conservation Districts (SWCDs) in providing federal technical and financial assistance to farmers for practices providing targeted agri-environmental public goods. SWCDs also work with state and local government agencies to implement state-initiated agricultural programmes.

Under Section 404 of the CWA, permits are required for filling wetlands. The section exempts filling that would result from normal farming activities, but not activities that would convert a wetland to upland due to new or expanded drainage. This permitting is administered by the US Army Corps of Engineers. Section 404 does not prohibit filling wetlands, but does require mitigation of the disturbance. Wetland mitigation banks are one method. A mitigation bank is a wetland that has been restored, established, or enhanced for the purpose of providing compensation for unavoidable impacts to aquatic resources permitted under Section 404 or a similar state or local wetland regulation. Banks may be created by private or public entity, and can sell mitigation credits to wetland developers as compensation for unavoidable impacts. The price per wetland credit is a private transaction between the bank sponsor and the buyer. Agricultural land can be a land source for mitigation banks. Conservation Banks are an analogous tool for endangered species habitat mitigation under the Endangered Species Act.

States play a large role using a variety of instruments determining the pricing and allocation of water. The Federal Bureau of Reclamation is also involved in providing water to agriculture in western states. Water law, institutions, and programmes are highly varied and complex across the states and are not addressed in this report. The focus here is on federal programmes explicitly aimed at addressing water quantity concern through on-farm conservation measures. There are examples of these measures being integrated with broader institutional water management to encourage on-farm conservation. These include making EQIP assistance for irrigation systems conditional on irrigated land expansion (Nebraska), providing special EQIP assistance to farmers in locations in which state authorities mandated water conservation for environmental flow protection (California), water price reductions for farmers in irrigation districts with water pricing tied to adoption of conservation practices (California), water markets enabling farmers who reduce irrigation to sell the savings (Oregon and other states), and use of the USDA CREP program to idle irrigated cropland (Nebraska, Colorado, Idaho, and Kansas)(Shaible and Aillery, 2012b).

Evaluations

Measured by participation, USDA conservation programmes are generally successful. EQIP is a popular programme with farmers, with demand exceeding available funds. In 2008, more than USD 487 million in requests for EQIP funding, equivalent to roughly 50% of what was actually spent went unfulfilled. The CRP has been similarly popular, though recent sign-ups indicate some shrinkage of landowner interest (Hellerstein, 2012). Strong commodities markets increasing the opportunity costs of participation are one possible factor (Hellerstein and Malcolm, 2011).

The size, multiple benefits, and complexity of agri-environmental public good pose enormous challenges to comprehensive ex-post economic evaluation of USDA conservation programmes. There is an ample literature demonstrating significant willingness to pay for water quality protection, wetlands conservation, wildlife habitat protection, and air quality protection.

However, information on the impacts of USDA programmes on environmental conditions is limited. The recent Conservation Effects Assessment Project focusing on water quality impacts underscores the issue while also providing a model assessing environmental outcomes (USDA NRCS, 2010, 2011a, 2011b). In addition to the challenge of determining the environmental outcomes and their economic values, another challenge is to separate out conservation investments that result from USDA programmes versus those that would occur without. For example, a major conservation success in the United States is the widespread adoption of conservation tillage practices. Such practices are supported by USDA programmes, but the private economics of adoption are also strong given significant fuel and labour cost savings from reduced tillage (Ebel, 2012). Cost-benefit analyses are conducted within the agency but must rely on limited existing data and limited resources.

While a comprehensive benefit cost analysis is not available, it is possible to raise significant questions about the cost-effectiveness of USDA conservation programmes based on the existing literature. The expansion of programme objectives from traditional soil quality to water quality, wetlands, and wildlife is clearly responsive to the source of the major societal benefits. But restrictions on targeting and a focus on practices rather than performance diminish effectiveness and efficiency (Shortle et al., 2012).

5.3. Agricultural landscapes

Market failure

Sources of economic benefits from agricultural land preservation have been concisely described by Gardener (1977) as food security, a viable local agricultural industry, amenities, and orderly and fiscally sound development. Subsequent taxonomies largely refine benefits within the broader categories and add protection against loss of local ecosystem services provide by agricultural land from urban development (Wolfram, 1981; Fischel, 1985; McConnell, 1989; Bromley and Hodge, 1990; Duke and Aull-Hyde, 2002; Lynch, 2007). Public policy initiatives to protect farmland early on emphasised food security concerns resulting from conversion of farmland to developed uses. Research indicating that conversion did not pose significant food security risks and recognition of the public goods from agricultural land in and around urban areas have refocused attention to the provision of public goods, especially rural amenities, from agricultural land as the most compelling justification for agricultural land conservation policies (Gardner, 1977; McConnell, 1989). Being public goods, landowners can receive no compensation for the provision of amenities or local ecosystem services provided by farm land, possibly resulting in suboptimal supplies without public policy intervention.

Concern for farmland preservation has led to state and local policy initiatives across the United States, but especially in the densely populated Northeast (Lynch, 2007). Indicative of the demand for such programmes is that they are often the result of referenda in which voters directly choose to create and fund preservation programmes. Also indicative of the demand are numerous studies demonstrating that people are willing to pay to protect farmland through various mechanisms (Bergstrom and Ready, 2009.)

Federal Policies

The USDA ACEP can provide financial support to state and local governments seeking to protect farm land from urban development and thus contribute to the provision of agricultural landscapes.

State and local policies

State and local government use a variety of methods. A common tool used by states is "right-to-farm" laws that protect farmers and ranchers from nuisance lawsuits and that may also prohibit local governments from enacting ordinances that would impose "unreasonable" restrictions on agriculture. Some states use agricultural use value assessments rather than market assessment of farm land values for property tax purpose. This reduces farm tax burdens when development pressures push market values above use values. Some states have created agricultural districts that allow farmers to form special areas where commercial agriculture is encouraged and protected. The protection offered by Districts vary across states, but include protections against local governments passing restrictions on farming, exemptions from private nuisance law suits, and eligibility for participation conservation easement programmes. Conservation easements are deed restrictions that landowners voluntarily place on their property to protect agricultural land (or other resources). Purchase of development rights programmes separate the rights to develop from farm land from other property rights, and remove the development right for some period, possibly into perpetuity. Some states provide funding for purchase of conservation easements or development rights. General obligation bonds are the most common method (AFT, 2006).

Others include general appropriations and dedicated taxes. As noted previously, USDA also provides funds for agricultural land preservation programmes. As of January 2010, at least 88 independently funded, local purchase of agricultural conservation easement programmes in 20 states had acquired funding and/or easements (AFT, 2010). Transfer of development rights (TDR) programmes are used within the context of land use zoning ordinances to enable agricultural landowners to sell development rights to their land to landowners in designated growth areas.

Evaluations

The American Farmland Trust reports that as of January 2005 more than 124 governmental entities in the United States have implemented farmland preservation programmes and over 1.67 million acres had been placed in protected status are now in preserved status at a cost of almost USD 4 billion (AFT, 2005a, 2005b). Economic research provides evidence that these programmes are providing net social benefits (Feather and Barnard, 2003; Duke and Ilvento, 2004; Bergstrom and Ready, 2009). However, analogous to other agri-environmental mechanisms, policies do not appear to be implemented to get the most from the resources allocated. In a review of farmland preservation legislation Nickerson and Hellerstein (2003) found that protection of rural amenities is the most frequently mentioned policy objective followed by food security and environmental services. However, they found that procedures for ranking properties for inclusion in preservation programmes used readily available production-oriented land and property characteristics, such as soil productivity, excluding indicators of nonmarket value.

6. Reference levels and agri-environmental targets for agri-environmental public goods

The OECD defines agri-environmental reference levels as the minimum level of environmental quality that farmers are *obliged* to provide *at their own expense* (OECD 2001). Agri-environmental targets are defined as desired levels of environmental quality that go beyond the minimum requirements or minimum levels of environmental quality for the agricultural sector. Definitions of reference and targets vary between and even within agri-environmental public goods types, and between federal, state, and local governments involved in agri-environmental public goods provision. Table 6 provides a summary of reference levels and environmental targets in the United States.

Table 6. Summaries of reference levels and agri-environmental targets in the United States

	Agri-environmental public goods						
	Soil quality	**Water quality**	**Water Quantity**	**Wetlands**	**Wildlife**	**Air quality**	**Agricultural landscapes**
Environ-mental targets	-Federal policy seeks soil conditions consistent with sustainability in soil productivity.	-Water quality standards established by state water quality authorities subject to USEPA oversight. -Agricultural load allocations in agriculturally impaired watersheds under TMDL provisions.	-Water resources are managed for multiple uses. Priorities vary within and across states -Federal policies seek to improve irrigation efficiency and other agricultural water management practices on irrigated lands	-Federal policy seeks no net loss and encourages expansion of wetland areas.	-Federal and state policies seek expansion and protection of habitat, especially for endangered species.	-Ambient levels established by the federal government. States can impose stronger requirements.	-Policies seek reductions in conversion of farmland to developed uses.
Reference level	-Generally undefined except for USDA cross-compliance programs -Voluntary compliance approaches imply farmers' choices are reference levels.	-Technology or water quality based effluent standards for concentrated animal feeding operations regulated as point sources -Farming practice standards in some states -Federal pesticide regulations -With few exceptions, water quality impacts are unregulated -USDA working lands and comparable programmes encourage water quality protections.	-Water rights and management institutions vary across the states. Water is variously treated as an open access good, an exclusive private property, and state property. State and federal laws can regulate use even when property rights are private.	-Reductions in wetlands and wildlife habitat subject to federal and state regulations. Expansions are subject to federal and state encouragements.		-With few exceptions, air quality impacts are unregulated. -USDA working and state and local working lands programmes encourage or mandate air protections.	-References levels generally undefined.

Some of these reference levels are implicitly set at what farmers are currently doing, and agriculture is exempt from regulations that require other sectors to meet certain environmental quality at their own expense. The Conservation Effects Assessment Project, a multi-agency effort to quantify the environmental effects of conservation practices and programs and develop the science base for managing the agricultural landscape for environmental quality, finds uneven environmental performance among farms with respect to stewardship standards developed by the agencies, and room for improvement in regions that have been assessed (USDA NRCS 2010, 2011a, 2011b, 2012a, 2012b 2013a, 2013b). Although acceptable environmental quality is different from the minimum environmental quality that farmers have to meet at their own expense (i.e. reference level), some agencies define standards for environment and conservation practices in agriculture, and utilise those as guidelines in developing and implementing voluntary conservation plans for farms

Soil quality

Soil quality protection programmes are generally voluntary compliance programs, with USDA or other agencies providing technical and financial assistance to farmers who seek it. Implicitly, reference levels are effectively the farm practices and environmental outcomes are selected by the farmer. An exception can from cross-compliance requirements for farmers with highly erodible lands under the "Sodbuster" provisions defined previously.

Water quality

Under federal law large concentrated animal feeding operations regulated as point sources of water pollution are required to comply with technology based effluent standards. Where applicable, these standards define a technology-based reference level with the costs of implementation borne by the producer. Some states expand the scope of regulation of concentrated animal feeding operations beyond the level required by the USEPA. Since technology based effluent standards must be met regardless of water quality conditions, environmental targets are irrelevant unless a TMDL has been established for the impacted waters. In this case, water quality based standards may be applied. TMDLs are based on established water quality standards (environmental targets) for impaired waters and may create targets for agricultural sector pollution loads in waters that are agriculturally impaired. The voluntary compliance approach that most states have taken to agricultural nonpoint sources implies that the reference levels for farm practices and environmental outcomes are effectively the levels selected by the farmer. There are exceptions to this approach, as noted in the discussion of state water quality regulation, with some states establishing minimum standards for farming practices. In such cases, technical or financial assistance for compliance may be available from USDA and possibly state sources. Water quality trading programs that include agriculture typically require farmers to meet minimum standards before being eligible to trade nutrient or sediment reduction credits. These requirements essentially create a practice-based reference that becomes applicable when farmers sell credits. These programs are generally designed for agriculture to benefit from pollution reduction activities by selling pollution reduction credits to point sources.

USDA programmes with water quality objectives are voluntary compliance programs that provide technical assistance and financial assistance to farmers adopting conservation practices. Implicitly, reference levels are effectively the farm practices and environmental outcomes are selected by the farmer.

Pesticide risks to water quality are regulated by the USEPA through determination of the pesticides that may be marketed and by labelling requirements that regulate use. Labelling requirements establish references for pesticide application practices.

Water quantity

Surface water in the United States is generally owned by someone, making agricultural reference levels contingent on property rights. Rights in water are defined by the states and often highly regulated. In the water rich Eastern United States, water rights have historically been governed by the Riparian Doctrine. Under this doctrine surface water rights attach to riparian land owners. These rights are typically not quantitatively fixed but require reasonable use. The Riparian approach does not serve well when water becomes scarce relative to demand and water must be allocated among competing uses. In consequence, many Eastern states have developed water management plans that set priorities for water use, and require water users to obtain permits (Griffin, 2006). In contrast, surface water is private property in some Western States where the Prior Appropriation Doctrine governs rights. The basics of this system are that water rights are transferable, involve quantification, and that conflicts over water is determined by seniority (Griffin, 2006). Some Western States blend the Riparian and Prior Appropriations Doctrines. A third form found in many irrigation districts and some river basins is Correlative Shares. In this case, private property rights exist as a share in the available resource. In addition to defining and regulation private property rights, governments designate some water resources as state property. Further the federal government is held to have certain reserved rights to water. The Federal Bureau of Reclamation (FBR) developed reservoirs in Western States beginning in the early 1900s through mid-century, and conveyances to supply water to various users including irrigators. FBR reservoirs are managed for multiple uses (irrigation, flood control, power generation, public water supply, environmental flows) with evolving priorities. Variants of surface water law are found in ground water law (Griffin, 2006).

Wetlands and wildlife

The United States and state constitutions provide significant protections to private property. These protections limit, though by no means prohibit regulation of land use for public welfare. Activities to restore or improve wetlands or wildlife habitat generally conflict with private property rights protections. However, as noted previously, evolving law and policy have diminished property rights allowing destruction of wetlands, or land use activities harmful to endangered species habitat, and the establishment of regulatory procedures. Essentially, these protections define reference levels for wetlands and wildlife in terms of harms to wetlands or endangered species relative to the status quo. The costs of these protections to the landowner are the private opportunity costs of the forgone land uses, or of activities to mitigate impacts.

Like farmers participating in water quality trading programs, participation in USDA programs can result in the application of reference levels for wetlands that would not otherwise apply. In this case, the exception is the result of cross compliance requirements with the “Swampbuster” provisions defined previously.

Air quality

Under the CAA, the federal government sets ambient air quality goals and directs states to development implementation plans for their achievement. These authorities could lead to reference levels and environmental targets for agriculture in regions that do not meet air quality standards. Agriculture has not been regulated historically under the CAA but policy in this area is evolving, as evident by recent initiatives in California. Nuisance laws provide a mechanism for addressing local problems but Right to Farm laws can exempt agriculture from this remedy.

Technical and financial assistance for air quality protection is provided by some USDA working lands programs. As these are voluntary compliance programs, reference levels are effectively the farm practices and environmental outcomes selected by the farmer.

Agricultural landscapes

Protections for agricultural landscapes are generally implemented through land use controls (zoning) or incentives that prevent or discourage the conversion of farmland to developed uses. Because these programs focus on preserving land in agriculture regardless of the farming practices conducted on the land, they do not define reference levels for farming practices or environmental outcomes applicable to farmers. Farm land owners bear the cost of zoning that prevents conversion to higher valued uses. This cost is offset in state or localities that use transfer of development rights schemes to distribute the costs of zoning regulations across zones. Farm land owners can benefit when preservation is encouraged through purchase of development rights, easements, and tax breaks.

Distribution of burdens

It is apparent from the above discussion that reference levels for agri-environmental public goods are often implicit rather than explicit, and are generally defined with respect to farming practices or land use, as opposed to environmental outcomes. Further, with some exceptions, reference levels imply that agriculture has a presumptive right to choose practices without regard to environmental externalities (Hodge and Bromley, 1990). Major exceptions are large concentrated animal operations, the use of pesticides, land use changes affecting wetland or endangered species, and highly erodible lands. This approach is sometimes warranted by extant property rights. Examples are farmland preservation programmes, programmes that contract with farmers to take crop land out of crop production and place in vegetative cover, and programmes that pay farmers to undertake habitat or wetlands restoration or enhancements.

In other cases, the voluntary compliance approach reflects historical approaches, and likely, the politics of moving from pay-the-farmer to the farmer-pays approaches. Current USDA programmes that are predominantly aimed at providing agri-environmental public goods (water quality, air quality, wetlands, wildlife habitat) emerged out of traditional voluntary soil quality programmes. The same is true of many state and local programmes. Agencies that administer such programmes commonly define standards for soil, water, nutrient management, and other farm practices affecting agri-environmental goods that are utilised as guidelines in developing and implementing voluntary conservation plans for farms. These standards can be means to enhance the environmental quality that farmers meet at their own expense, but the voluntary nature of compliance sharply distinguishes them from the mandatory nature of the OECD reference level concept.

Payments to agriculture for activities that provide positive externalities (e.g. wetlands creation, habitat restoration or creation, farm land preservation) seem uncontroversial. However, payments to agriculture to reduce environmentally harmful activities pose ethical questions given general acceptance of the polluter-pays-principle (PPP) for environmental regulation. The application of PPP has been variable in practice in the United States, with polluters in some sectors (e.g. municipal wastewater treatment facilities) receiving some public assistance for implementing mandated pollution controls. But agricultural water quality programmes, are at the pay-the-polluter (PTP) end of a PPP-to-PTP continuum (Shortle et al., 2012). While the appropriate location on this continuum is an ethical and political decision, a strong case can be made for moving further toward a PPP approach in the current budgetary environment. The current approach makes progress towards water quality goals contingent on some combination of increased spending and/or increased efficiency in the use of resource to target resources where they are most needed and to incentivise environmental performance adoption of practices or land retirement (Shortle et al., 2012). While the federal conservation budget has grown for years, the current budgetary environment does not seem favourable. The PPP paradigm is not costless for public agencies, but it would reduce budgetary challenges inherent in the PTP approach.

7. Conclusions

Beginning in the 1960s the conception of the goods from agriculture began to change as it was recognised that agricultural activities, including conversion of land to or from agriculture, have "off-farm" environmental consequences. Attention was initially focused on adverse impacts on water quality conditions resulting from runoff carrying pesticides and fertilisers, and soil eroded from intensively tilled lands, into water resources. The catalogue of environmental conditions affected by agricultural production has been refined and expanded with improved understanding of the relationships between agricultural land use and environmental conditions, and the environment as affected by agriculture, and human well-being. This catalogue includes beneficial impacts of agriculture as well as the negative impacts.

United States agri-environmental policies target a subset of broadly defined agri-environmental public goods within a wider domain of possibilities. These goods are soil quality, air and water quality, water quantity, wetlands, wildlife, and agricultural landscapes. These choices, and the policies used to manage their provision, emerge from the division of responsibilities for agri-environmental public goods, across national, state, and local authorities, delegation of federal authorities to state and local governments for implementation, overlapping programmes across levels of government, and the multiple agencies with authorities for agri-environmental policies at various levels of government.

The direction of agricultures' influence on specific environmental conditions in specific locations depends on the alternatives under consideration. For example, some agricultural practices are more harmful to air or water quality, biodiversity, or global climate than others. In consequence, changes in agricultural practices can increase or decrease the supply of environmental public goods. An alternative comparison is between agricultural and non-agricultural land uses. Agriculture is generally ecologically disruptive compared to forests or native landscapes. However, urban land uses generally poses a far greater risk to air and water quality, and ecosystem services, than agricultural production in the same location. Accordingly, agricultural land use can be viewed as supplying environmental public goods when compared to some alternatives, and the opposite when compared to others. These distinctions are important when considering US laws, policies, and programmes for agri-environmental public goods. Some are intended to increase the supply of such goods by encouraging or mandating practices that are less harmful to the environment than current practices on working lands. Others are intended to increase the supply of such goods by converting environmentally sensitive agricultural lands to permanent vegetative covers, preventing or limiting the conversion of environmentally sensitive lands to agricultural production, and limiting conversion of agricultural land to more developed uses. All four approaches are implemented to varying degree by federal, state, and local governments as part of laws, policies, and programmes for environmental protection and resources conservation.

Research indicates that United States agri-environmental programmes are providing environmental benefits that are valued by citizens. Areas of noteworthy accomplishment include reductions in pesticide risks to the environment, improvements in soil quality protection, and a reversal of the negative impacts of agriculture on wetlands areas and wildlife habitat. Water quality protection is, however, an area where current agri-environmental policies are not achieving established goals, leaving agriculture as a leading cause of water quality problems. Policy reforms are essential for progress on water quality. Further, a pervasive weakness in United States agri-environmental policies is that they are not cost-effective. This is a result of policies that are not designed to efficiently achieve explicit agri-environmental public good outcomes (Shortle et al., 2012, Nickerson and Hellerstein, 2003). This inefficiency is the result of policy designs that do not adequately target resources to locations and activities according to potential environmental benefits, that facilitate and finance effort rather than outcomes, and in the case of negative externalities, that allow producers too much discretion about their environmental performance. This inefficiency is highly problematic given the overwhelming reliance of agri-environmental programs on payments to farmers. Society is not getting the most from the resources devoted to agri-environmental public goods provision (Shortle et al., 2012). Policy reforms to improve cost-effectiveness could help address the slow progress of water quality protections, and help address pressures on agri-environmental public goods provision that may emerge with federal and state budgetary pressures.

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