Special Article


Agricultural Research Service

Farmers' Use of "Green" Practices Varies Widely

Farmers increasingly face economic and societal pressures to convert from traditional or conventional production systems to "green" practices that are potentially friendlier to the environment. "Green" practices are known variously as improved practices, best management practices, conservation practices, water quality practices, environmentally friendly practices, and in some settings, sustainable and organic practices.

Such practices may be applied at various stages of production management. Farmers frequently use more than one green practice, and some may potentially contribute to multiple environmental goals. Which techniques are actually friendlier to the environment depends on where, when, and how they are applied, and on climatic factors in a given year.

Farmers are the primary decisionmakers on how they will combine land, water, commercial inputs, labor, and their management skills into systems and practices that produce food and fiber. To sustain production over time, farmers must make a profit and preserve their resource and financial assets. At the same time, society at large wants not only food and fiber at reasonable prices, but also products that are safe to consume and aesthetically pleasing, and production systems that preserve or even enhance the environment. The often competing goals and pressures are reflected not only in the inputs made available for production, but also in the methods of combining and managing the inputs.

USDA's Economic Research Service recently released information on farmers' use of some key green practices in *Agricultural Resources and Environmental Indicators: 1996-97*. Relying mostly on USDA's Cropping Practices and Chemical Use surveys conducted annually from 1990 to 1995 for major field crops, and biennially for selected fruits and vegetables, the report reveals that farmers' use of green practices varies widely among crops and from year to year. While few obvious trends could yet be identified, the data provide some measure of the extent of green practices in use compared with traditional or conventional practices.

"Green" Practices for Pest Management . . .

Most farmers currently rely on pesticides to control the insects, diseases, and weeds that cause significant yield and quality losses to U.S. crops. Two general management systems utilizing green practices can be employed in pest management. *Integrated pest management (IPM)* combines efficient use of chemical pesticides with cultural, biological, and other nonchemical methods aimed at controlling pests economically while minimizing danger to human health and environmental quality. *Ecologically based pest management* focuses primarily on nonchemical methods.

Scientists have developed pest scouting, economic thresholds, and other *pesticide-efficiency techniques* to help producers determine when to make pesticide applications, which pesticides to use, and how much to use. The techniques of *pest scouting* and *economic thresholds* are widespread in specialty crop production. Scouting involves checking a field for the presence, density, and developmental stage of weeds, insects, or diseases. Economic thresholds are pest population levels that, if left untreated, would likely result in reductions in revenue that exceed treatment costs. Growers use these threshold levels, developed primarily by land-grant university scientists, to determine when pesticide applications are economically justified.

Nearly two-thirds of fruit and nut acreage and nearly three-quarters of vegetable acres were scouted for insects in 1991-92, mostly by chemical dealers, crop consultants, and other professionals. Potato growers reported that 85 percent of their acreage was scouted in 1993, and thresholds were used in making insecticide application decisions on nearly three-fourths of their acreage.

Growers of two-thirds to three-fourths of corn and soybeans over the period 1990-95 reported scouting, mostly by themselves or a family member, and use of thresholds. Insect pests cause large economic losses in cotton production, and entomologists have been developing thresholds for these pests for several decades. Nearly 90 percent of cotton acreage was scouted in 1990-95—40 percent by commercial scouting services.

Another pesticide-efficiency technique is the *application of herbicides in bands or strips*, rather than broadcast over the field. This technique, which can reduce per-acre application rates, was practiced on about one-third of cotton acres during 1990-95, but on only 4-9 percent of corn and soybeans and 1-4 percent of fall potatoes. *Applying herbicides only after planting and weed*

Major Sources of Data on Farmers' Use of "Green" Practices

The **Agricultural Resource Management Study (ARMS)**, developed from combining USDA's Cropping Practices Survey (CPS) and Farm Costs and Returns Survey (FCRS), was conducted by the National Agricultural Statistics Service (NASS) for the first time in 1996. The ARMS poses questions about agricultural resource use and costs, farm sector financial conditions, and farm production practices, including Integrated Pest Management (IPM), on major field crops.

Chemical Use surveys, part of USDA's Pesticide Data Program (PDP), were initially funded under the 1989 President's Food Safety Initiative. The objective is to improve the pesticide data base by establishing pesticide residue monitoring activities and by expanding pesticide use surveys. Fruit and vegetable crops are the primary target of the survey program, with even-year surveys to cover vegetables and odd-year surveys to cover fruits and nuts. In each year, certain commodities are targeted in order to obtain more comprehensive information on management practices and costs for those commodities. A significant emphasis has been placed on collecting data on IPM and on organic production.

Cropping Practices Surveys (CPS) and predecessor surveys were conducted annually by NASS from 1964 through 1995, and merged into the ARMS in 1996. The CPS collected annual data on fertilizer and pesticide use, tillage systems, crop sequence, and data on other inputs and cultural practices. Fertilizer information has been reported from these surveys since 1964. In the mid-1980's, pesticide use, tillage operations, and prior crop questions were added to the survey. IPM and nutrient management questions were included in the 1990's. The final 1995 CPS gathered data on corn, cotton, soybeans, wheat, and potatoes and represented about 182 million acres, including acreage in major producing States and accounting for 70-90 percent of total U.S. acreage for these crops. Due to changing information requirements and funding, the number of surveyed crops and States varied from year to year.

The **Crop Residue Management (CRM) survey** is conducted annually by the Conservation Technology Information Center (CTIC), a division of the National Association of Conservation Districts, to provide State and national statistics on adoption of alternative crop residue management systems for all U.S. planted cropland. The CRM survey provides estimates on five different tillage systems: no-till, mulch till, ridge till (30 percent or more residue); reduced till (15-30 percent residue); and conventional till (less than 15 percent residue). A panel of local directors of USDA program agencies and others knowledgeable about local residue management practices complete the survey each summer as a group effort. These local judgments are summarized to provide State, regional, and national estimates. Several States also conduct physical surveys of crop residue levels for validation of the panel-derived estimates.

The **Farm and Ranch Irrigation Survey (FRIS)** is a follow-on survey to the U.S. census of agriculture. The FRIS, conducted in 1979, 1984, 1988, and 1994, has followed the last four agriculture censuses. The survey is based on a sample of producers reporting irrigation use in the census, excluding irrigation in Alaska and Hawaii and on horticultural specialty, institutional, experimental, research, and Indian reservation farms. Data are collected on irrigation water sources, costs, application technologies and frequency, crop yields, water conservation activities, and water management practices, covering from 17 to, most recently, 24 crops.

emergence, a technique which can leave lower herbicide residues in the soil, was used on 52-72 percent of fall potatoes during those years; 20 percent or more of corn, soybeans, and wheat; but just 10 percent or less of cotton acres.

Biological methods for managing pests include the use of pheromones, pest-resistant varieties, and beneficial organisms such as *Bacillus thuringiensis* (Bt) and pest predators and parasites. In the early 1990's, fruit and nut growers used *pheromone traps* on 37 percent of the surveyed acreage, *pest-resistant varieties* on 22 percent, and *beneficial insects* on 19 percent. Use of these practices on vegetables was much lower at 3-7 percent. However, 46-75 percent of organic vegetable growers used at least one of these practices. *Foliar application of Bt*, a microbial substance that kills certain insects, ranged from 1 percent of corn acres to 9 percent of cotton and over 50 percent of some specific fruits and vegetables in 1994-95.

Bioengineered insect-resistant varieties of corn, cotton, and potatoes were approved for commercial production in 1994-96. Bt-enhanced seed was used on 3 percent of corn acreage in 1995. Results are being closely monitored because of concerns that widespread use of bioengineered Bt varieties will accelerate development of pest resistance to foliar Bt treatments.

A number of *cultural production techniques and practices* can be effective in managing crop pests. These include crop rotations, mechanical cultivation for weed control, alterations in planting and harvesting dates, trap crops, sanitation procedures, irrigation techniques, soil fertilization, physical barriers, border sprays, and habitat provision for natural enemies of crop pests.

Use of *crop rotations*, one of the most important of the current cultural techniques, varies among crops and production regions. Most corn, soybeans, wheat, and potatoes are grown in some kind of rotation. In contrast, less than one-third of cotton acres is grown in a rotation; cotton's high per-acre returns provide incentive for continuous planting. Corn production has provided an example of the effectiveness of crop rotation in reducing pesticide use—only 11 percent of producers rotating corn with other crops in the early 1990's used insecticides, compared with 46 percent of those who planted corn 2 years in succession.

Weed control through cultivation is widely practiced for row crops, mostly in conjunction with herbicide use. Almost all of the potato and cotton acreage received cultivations in 1995, versus only 66 percent of corn and 41 percent of soybean acreages. *Field sanitation* (removing or destroying plant materials that encourage pests) is widely used on fruit and nut crops, with 60 percent of all fruit and nut acreage under this practice in the early 1990's. *Adjusted planting dates* to avoid high insect periods were used as a cultural control by over half of organic vegetable growers and on 15 percent of the surveyed area in vegetables. *Water management* (for maintaining healthy plants or hindering insect activity) was used by 44 percent of certified organic vegetable producers, and on 31 percent of all fruit and nut crop acreage.

Research continues on new cultural techniques such as solarization—heating the soil to kill crop pests. However, most cultural practices do not involve a marketable product, and research and development depends almost entirely on public-sector funding. In addition, while cultural practices may be effective for controlling pests, reducing pesticide use, and lowering input costs, these techniques require a knowledgeable producer and increased management.

. . . & for Nutrient Management

Nutrients applied to soil, which are essential for ensuring adequate crop yields and profitability, have long been associated with surface-water and groundwater contamination. Improved nutrient management practices attempt to foster crop yields and profitability while minimizing the loss of nutrients into the environment. Improved practices exist for each of the steps in nutrient management: assessing nutrient needs, product selection, timing nutrient application, nutrient placement, and cropping management. The efficacy of each practice is strongly influenced by field conditions, operators' management knowledge and skill, economic factors, and weather.

Assessing nutrient needs. Most acreage of major crops receives commercial fertilizer each year. Farmers following conventional practices often apply fertilizer at rates based on optimistic yield goals and may not take into account the nutrients already available in the soil. Improved nutrient management requires more information about the available nutrients in order to avoid over- or underapplication.

Soil tests for available nutrients can help improve nutrient management, although many farmers do not conduct annual tests of their fields. Over 1990-95, use of soil testing ranged from over 80 percent of potato acres in major producing States to about one-fifth of wheat acres. Soil testing of corn, soybean, and cotton acres ranged from 25 to 41 percent. The extent of soil testing of these crops varied from year to year. During the 1990-95 period, soil testing increased on lands being planted to wheat and cotton.

Testing of plant tissues for nutrient deficiency during the growing season allows farmers to apply fertilizers initially at low rates based on realistic or average yield expectations, and then to detect and correct any deficiency in nutrients that might result from rapid plant growth under better-than-average growing conditions. In 1994, the only year in which data were collected on tissue testing, farmers used the practice on 61 percent of potato acres and 12 percent of cotton acres, primarily to determine nitrogen deficiency. No data were collected for other crops.

Improved nutrient management should *account for nutrients provided by other sources*. Up to 17 percent of the acreage in major crops received manure application in 1990-95. Analysis of the nutrient content of manure allows farmers to factor this in when determining additional nutrient needs from other sources. Data for 1994 and 1995 indicate that manure analysis occurred on 30-40 percent of cotton and potato acres receiving manure, but on only 6-12 percent of corn and wheat acres receiving manure.

Previously planted legumes provided nutrients to about half of the corn acres and up to one-fifth of the potatoes in the major growing States during 1990-95. On about half of the corn acres with previous legumes, and most of the potatoes, farmers reported either soil testing or giving credit for the legumes in determining commercial nutrient needs.

Nutrient product selection. *Nitrogen stabilizers or inhibitors* (urease inhibitors and nitrification inhibitors) delay the transformation of nitrogen fertilizer from ammonia into nitrate and help time the nitrate supply to peak plant demand. The potential for economic benefit from nitrification inhibitors is greatest where soils are poorly or excessively drained, no-till cultivation is used, nitrogen is applied in the fall, crops require a large amount of nitrogen fertilizer, or excessively wet soil conditions prevent the application of nitrogen during the growing season. The practice is not widely used. During 1990-95, farmers used nitrogen inhibitors on 5-10 percent of corn acres, and on even less of the area in cotton, fall potatoes, and winter wheat.

Timing nutrient applications. In addition to assessing nutrient needs, timing applications to the biological needs of a crop leaves less nitrogen available for leaching, runoff, denitrification, and other losses, potentially reducing the total amount applied. For example, corn requires most of its nitrogen supply in midsummer. If nitrogen is applied either in the fall or early spring before planting, it is more readily lost to the environment than if applied at or after planting, and farmers often apply a larger amount to make up for the anticipated loss.

Economic considerations can lead farmers to apply nitrogen during fall and spring rather than during the growing season. Uncertain weather conditions may shorten the window in which fertilizer can be applied during the growing season, increasing the risk of yield loss from inadequate nitrogen availability. Farmers' opportunity cost of labor and application arrangements may be significantly higher during the late spring and growing season, when labor and machinery demands are at a peak, than during the fall, when most farmers experience a relatively slack

Glossary of "Green" Practices Terminology

Pest Management

Pest scouting involves checking a field for the presence,density, and/or developmental stage of weeds, insects, or diseases. Insect pests, for example, can be scouted by using sweep nets, leaf counts, plant counts, soil samples, and general observation.

Economic thresholds are levels of pest population that, if left untreated, would result in reductions in revenue that exceed treatment costs. The use of economic thresholds in making pesticide treatment decisions requires information on pest infestation levels from scouting.

Application of herbicides in bands or strips spreads herbicides over, or next to, each row of plants. Banding herbicides often requires row cultivation to control weeds in the row middles.

Applying herbicides only after planting and weed emergence (post-emergence) is considered more environmentally sound than applying pre-emergence herbicides because post-emergence herbicides have little or no soil residual activity.

Bacillus thuringiensis (Bt) is a bacterium used to control numerous larva, caterpillar, and other insect pests in agriculture. Bt is most often applied directly to the leaves of plants, but some new varieties of corn contain natural genes and bioengineered genes produced from the soil bacteria Bt to give them host–plant resistance to certain insect pests.

Pheromones, biochemical agents that attract insects and modify their behavior, are used in traps or lures to draw insects away from plants in the field.

Beneficial organisms are pest predators and parasites that are used to control crop pests and weeds.

Crop rotation involves alternating the crops grown in a field on an annual basis, which interrupts the life cycle of insect pests by placing them in a non-host habitat.

Weed control through cultivation or tillage can destroy pests in a variety of ways, for example, by directly destroying weeds and volunteer crop plants in and around the field.

Field sanitation procedures remove or destroy crops and plant material that are diseased, provide overwintering pest habitat, or encourage pest problems in other ways.

Adjusted planting dates can be used to avoid periods of heavy pest infestations. Delayed planting of fall wheat seedlings may help avoid damage from the Hessian fly, for example.

Water management can be used as a pest management technique either directly, by hindering pest activity, or indirectly, by improving the overall health of the plant and, in turn, its ability to resist pests.

Nutrient Management

Soil and plant tissue testing provides information about the nutrient levels in the soil or plant tissue and helps farmers match application of fertilizer to crop needs.

Nitrogen stabilizers or inhibitors delay the transformation of nitrogen fertilizer from ammonia to nitrate and help match the timing of nitrate supply with peak plant demand.

Precision farming is a technology that divides whole fields into small areas and uses a variable- rate fertilizer spreader and a global positioning system to apply the exact amount of nutrient needed at a specific location.

Cover crops planted between crop seasons can reduce nutrient loss by preventing the buildup of residual nitrogen in the soil and minimizing soil erosion.

Rotating nitrogen-using crops with legumes adds nutrients to the soil and reduces the need for fertilizer.

Banded application of fertilizer next to the plant or seed, as opposed to broadcasting, reduces loss of nutrients.

Irrigation Management

Pressurized sprinkler irrigation uses pressure to spray water over the field surface, usually from above-ground piping. Compared with gravity-flow irrigation that relies on gravity alone to distribute water across the field, sprinkler irrigation usually permits better adjustment of water application to the needs of the crop and reduces water and nutrient loss.

Low-flow irrigation, including drip, trickle, and microsprinkler systems, is a pressurized system that applies water in small, controlled quantities near or below ground level.

Soil moisture sensing devices and commercial irrigation scheduling help farmers determine when and how much water to apply.

Crop Residue Management

Reduced tillage includes tillage types that leave 15-30 percent residue cover after planting, or 500-1,000 pounds per acre of small grain residue equivalent throughout the critical wind erosion period.

Conservation tillage includes any tillage and planting system that maintains at least 30 percent of the soil surface covered by residue after planting to reduce soil erosion by water, or at least 1,000 pounds per acre of flat, small grain residue equivalent on the surface throughout the critical wind erosion period. Weed control is accomplished with herbicides and/or cultivation. Types of conservation tillage include:

No-till, in which the soil is left undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot. Weed control is accomplished primarily with herbicides.

Ridge-till, in which the soil is left undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges that are rebuilt during cultivation. Residue is left on the surface between ridges.

Mulch-till, in which the soil is disturbed prior to planting, but less intensively than reduced or conventional tillage.

period. Fertilizer pricing patterns (lower in the fall than spring) also tend to encourage fall application.

Nevertheless, during 1990-95, growers of corn, cotton, and potatoes generally avoided applying fertilizer in the fall on about two-thirds or more of the acres, and in the spring before planting on about half of the acres.

Nutrient placement. For the major crops surveyed in the Cropping Practices Survey, broadcasting—spreading fertilizer across the whole field—was the dominant method of applying fertilizers. Broadcasting has a relatively low field application cost, but broadcast nitrogen is more susceptible to loss to the environment. In contrast, *banded applications*—including injection, knifed-in, or side dressing—place nitrogen fertilizer closer to the seed or plant for increased crop uptake and reduced leaching and volatilization. Moreover, banded applications can result in higher yields. While the per-acre operation cost of injection applications is higher than the per-acre operation cost of broadcast applications, the overall cost is generally lower because of lower fertilizer expenses. During 1990-95, banding was practiced on one-fifth of the cotton and winter wheat acreage, and 40-51 percent of the acres in corn and fall potatoes.

Precision farming, also referred to as site-specific farming, is a promising new technology for improving nutrient placement. Precision farming divides whole fields into small areas and uses a variable-rate fertilizer spreader and a satellite-guided global positioning system (GPS) to apply the exact amount of nutrient needed at each area to achieve the expected yield. Assessments are underway on how precision farming affects yield, fertilizer use, farm-level profitability, and the environment.

Crop selection and management. *Rotating nitrogen-using crops* with a nitrogen-fixing legume crop can reduce the need for commercial fertilizer. Legume crops at the early stage of growth absorb residual nitrogen in the soil and reduce nitrate leaching. In addition, crops in rotation reduce soil insect problems, improve plant health, and increase nitrogen uptake efficiency. Most potatoes, three-fourths of corn, and 49-61 percent of winter wheat acres were grown in rotations during 1990-95.

Planting *cover crops*—such as small grains or hairy vetch—between crop seasons can improve soil fertility and texture, absorb residual nitrogen during dormant seasons, and reduce nutrient loss to the environment. Because planting cover crops contributes little to current profits, few farmers use the practice.

"Green" Management of Irrigation Water . . .

Improving the management of irrigation water can protect the environment by, for example, increasing stream flow and by reducing nutrient losses and soil erosion. Excessive irrigation water applications can carry nutrients and other pollutants into offsite water systems and can increase nitrogen leaching, reducing nutrient concentration in the soil and lowering plant uptake. Too little irrigation water, on the other hand, can stunt plant growth, reducing crop nutrient uptake and increasing residual nutrient levels susceptible to storm runoff.

Farmers have been improving irrigation water management by switching from gravity-flow irrigation to pressurized sprinkler irrigation, by scheduling irrigation according to plant needs, and by using improved gravity irrigation practices. The cost of irrigation improvements can be substantial, but for many farmers the economic benefits from higher yields and savings on water, labor, and nutrient expenses offset the cost.

Gravity-flow irrigation has been decreasing in most regions, and sprinkler irrigation increasing. Sprinkler systems now irrigate nearly half of total irrigated area, up from 37 percent in 1979. Nearly two-thirds of sprinkler systems were center pivot in 1994, up from less than one-half in 1979, giving farmers even greater control of water applications. In addition, more irrigators are using soil moisture sensing devices to determine when water is needed—10 percent in 1994, up from 8 percent in 1984—as well as commercial irrigation scheduling, up to 5 percent in 1994 from 1984's 3 percent.

An emerging technology with potential to achieve optimal plant moisture is low-flow irrigation, a pressurized method in which water is applied in small, controlled quantities near or below ground level. Field application efficiency of 95 percent or greater (water loss of 5 percent or less) can be achieved under low-flow systems, although proper design and management are required to avoid crop moisture stress and soil-salinity accumulation. Low-flow irrigation systems—including drip, trickle, and micro-sprinklers—are used on 4 percent of irrigated cropland acreage, up more than fourfold since 1979. Low-flow systems are used most commonly for production of vegetables and for perennial crops such as in orchards and vineyards, although experimentation and limited commercial applications on some row and field crops are occurring.

. . . & Crop Residue

Potential long-term environmental benefits of "green" management of crop residue include reduced erosion and surface runoff, cleaner surface runoff, higher soil moisture and water infiltration, improved soil organic matter and long-term productivity, and improved air quality through reduced release of carbon gases. Practices for managing residue from the previous crop include removing it, burning it, incorporating it into the soil, or leaving it on the soil surface. While farmers once took pride in clean-tilled fields free of surface residue, increasingly they are using tillage practices that leave 15 percent or higher residue cover on the soil surface after planting.

Conservation tillage leaves 30 percent or more of the soil surface covered by crop residue after planting, and *reduced tillage* leaves 15-30 percent residue coverage. In 1996, farmers practiced conservation tillage on over 35 percent of planted acres, up from 26 percent in 1990, and reduced tillage on about 26 percent. Use of conservation tillage has been growing, and conventional tillage decreasing, primarily because of farmers' expanded use of *no-till*, a form of conservation tillage that leaves the soil undisturbed from harvest to planting except for nutrient injections. No-till use occurred on nearly 15 percent of land planted to crops in 1996, up from 5 percent in 1989. The highest relative

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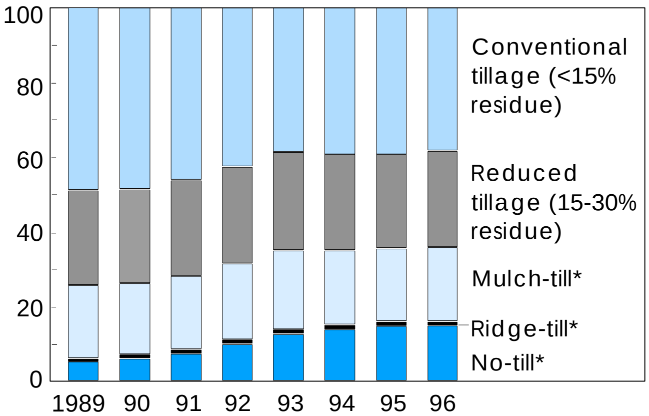
Use of Conventional Tillage Declines as Use of No-Till Grows

Percent of planted acres



*Conservation tillage (30% or more residue).
Economic Research Service, USDA

use of no-till was on corn and soybean acreage, with the most rapid expansion occurring for soybeans. Use of no-till on wheat and other small grains is more limited but steadily expanding.

Farmers planting crops on highly erodible lands are required by USDA's Conservation Compliance Program to have an implemented conservation plan to protect soil from erosion. In addition, farmers generally wish to preserve the fertility of their soils. These factors have stimulated greater use of conservation tillage on highly erodible lands than on less erodible lands. But on many soils and in many field situations, conservation tillage also results in lower costs—requiring fewer trips over the field—while maintaining or increasing yields.

While crop residue management is environmentally friendly in terms of sediment reduction, whether it is also friendly in terms of pesticide use and loss to the environment remains under study. Both the quantity and mix of pesticides used under different tillage practices need to be examined, as well as the movement offsite of residuals in water or attached to sediment.

Farmers' use of green practices is being promoted in various conservation and water quality programs and through expanded information dissemination by government agencies, universities, and equipment manufacturers. Improvements are also being made in applicability and economic feasibility of many green practices.

While use of green practices has varied from year to year and by crop and area, some positive trends are becoming apparent. Starting in 1996, data gathering began on practices used with major field crops, as part of USDA's new Agricultural Resource Management Study (ARMS). As additional years of data are compiled and analyzed, trends may become apparent for more of these practices.

Richard Magleby (202) 694-5615,rmagleby@econ.ag.gov. With Marcel Aillery, Noel Gollehon, Catherine Greene, Wen-yuan Huang, Merritt Padgitt, and Carmen Sandretto AO