United States Department of Agriculture

Natural Resources Conservation Service
Conservation Effects Assessment Project

CEAP Conservation Insight

September 2014

Modern Sustainable Production Needs for Pasture and Forage Systems

Summary of Findings

- Most conservation practices reviewed are effective in soil and water conservation, but would benefit from monitoring and landowner education.
- Sustainability is being redefined to include resilience, i.e., the ability to be consistent over years in conservation effectiveness, production, and other services.
- Expectations of sustainable systems have expanded to include more social and wildlife benefits that are hard to evaluate economically.
- Ecological economists are developing methods that are needed to evaluate social and biodiversity outcomes from practices.
- More long-term research is needed to address adaptive management outcomes and changes in ecological issues associated with sustainability and resilience.
- Emerging issues to address include climate change, water use and quality, energy issues, and changes in food consumption patterns.
- Standardized monitoring of installed conservation practices and uniform analysis methods are needed to crosswalk information between research, modeling, and decision-making.

Background

Expanded public expectations are pressuring agriculturalists to ensure that management systems are sustainable for the long term to meet local, national and international goals for food production and quality. These goals now extend beyond the farm to include more factors and to involve new interpretations of appropriate balances between economically viable and environmentally sound practices, while managing pastures and livestock systems in socially acceptable ways.

The Conservation Effects Assessment Project (CEAP) on pasturelands is designed to quantify the conservation benefits of practices on privately-owned grazing lands in the United States. Science-based literature was assessed to determine the effectiveness and applicability of the "purpose" statements contained within selected USDA NRCS conservation practices. Identified purposes of conservation practices are intended to provide opportunities for resource conservation on working agricultural lands. As part of the effort, research scientists considered how long-term changes in forage species and their management could provide sustainable and resilient agriculture that preserves the ecosystem. This first comprehensive assessment brought many new insights to the nature of the problem and potentials for science-based practices that would benefit the system. This Conservation Insight evaluates sustainable systems related to changing trends in conservation needs on forage and grazing lands.

Modern Sustainable Production

The public has expanded expectations from agriculture, beyond food, to manage natural resources in a sustainable way that focuses on conservation and social goals. For example, economic return has been extended to add storage, processing, preservation, and preparation of food stuffs; in essence encompassing the "field to the fork." The view of sustainability will take long-term studies using current and new methodologies in analyses of biodiversity, plant and animal ecology, health sciences, social sciences, and cultural sciences to develop and evaluate sound conservations practices and policies for the new definition. The goal of each conservation practice within an ecosystem concept should lead to a more sustainable condition.

Current emphasis includes adding *resilience*, the ability to perform consistently every year. This is partially in response to more variable weather events associated with global climate change, to achieve national priorities on food security, and to meet international goals of stable product and food prices. Cultivars and crop management systems will need to *consistently* provide the needed quantity and quality of food in a sustainable manner, along with increased efforts to provide the range of other desired goods and services. Potential drastic events involving weather variables, disease, or insect outbreaks against vulnerable cultivars must be mitigated, and even calamities such as wars and terrorism affect resilience. These drastic changes are often abrupt and localized.

Need for Long-Term Research

The CEAP pastureland assessment documented that science supported purposes and criteria of most NRCS conservation practices, especially for factors affecting production. However, most experiments included only one or two methods to evaluate effects on soil quality or water quality; few studies included plant biodiversity and wildlife. Ecosystem-based experiments need to be comprehensive, involve diverse scientists, and be long-term to foster ecosystem stability. International connections will assist with methodologies and data acquisition. Strong partnerships among state universities and Federal agencies will add comprehensiveness to the long-term investments. Monitoring of installed conservation practices to gain information would be a great help to the research community and should be considered in the management plan. Standardized sampling and analysis methods during monitoring would facilitate data transfer and use for models. A similar recommendation for standardizing measurements arose regarding fish and wildlife benefits from the Wildlife Habitat Incentives Program (WHIP).

Economic Assessments

Production and ecosystem costs of lost soil and impaired water need to be quantified. Funding incentives have been used to encourage practices for conservation. Monitoring and cost-benefit data are needed to demonstrate the true value of each conservation practice with time.

When personal incomes increase, the public will pay more for food that is produced in ways that are presumed safer, healthier, or result in better quality that are not direct components of sustainability. Labels such as "organic," "natural," "grass fed," "healthy," or "locally grown" entice consumers to pay a higher price to offset the reduced yield or higher production costs. At high income levels, price premiums for products produced while preserving wildlife diversity and aesthetics are emerging in Europe and will grow in importance in the U.S. Some, but not all, sustainable production practices can be funded partially or wholly by value-added marketing. Many diversity and social services benefits derived from agriculture will depend on other funding strategies.

Future Considerations for Conservation Practices

Myriad emerging issues will need the attention of NRCS and the new generation of Conservation Practice Standards (fig. 1). Some are already well developed. International relations on trade (e.g., mad cow disease, hay marketing), roles of genetically modified plants, responding to climate change, energy production

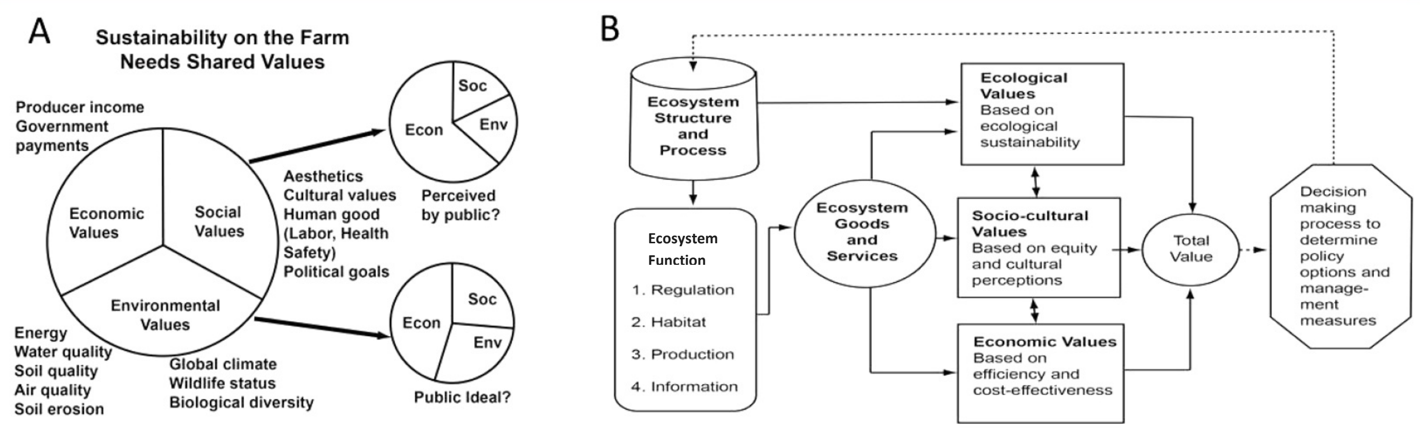

Figure 1. Early definitions of sustainability at the farm or ranch level (**part A**) were categorized as economically viable, environmentally sound and sociologically acceptable. This can be depicted as a divided circle, but the segment sizes differ markedly depending on the crop, the management used, and, especially, perspectives of the public on environmental and social issues. Now, sustainability is being reconsidered (**part B**) to include more ecosystem goods and services based on expanded ecological and socio-cultural values. **Part B** adapted from de Groot et al. 2002. Ecol. Econ. 41:393.

and conservation, and residues from pharmaceuticals, probiotics, and *E. coli* should be on an exhaustive list. These and others will require collaboration with a broader range of disciplines and new partners including social scientists. Each ecosystem service has its own timeline, degree of public support, relative importance, economic value, and scientific uniqueness that will require it be dealt with in its own way.

Modern sustainability and resilience. Public perception is that farmers place greatest emphasis on economic production with little consideration of environmental and social effects during long-range planning and daily decision-making (fig. 1). As society develops and personal income increases, there is more public emphasis on 1) environmental issues, 2) food safety, 3) food quality, and finally 4) increased biodiversity of plants and animals. Addition of each service reduces the rate of production gain due to "fitness penalties" and the altered management needed to achieve the greater number of goals. Current public pressure is on resilience, the *E. coli* challenges, and food quality, which is associated with freshness and taste. Emphasis is on eating *healthy*, including locally grown food that is fresh and often organic. More emphasis on wildlife and other forms of biodiversity are expected to be part of sustainability. The trend for healthy food has been accompanied by dietary shift to more vegetables and fruits, less red meats and other foods that have high fat content (fig. 2). Using defensive measures in crop management to gain resilience will likely result in short-term yield reduction as more conservative practices are used. Regardless, the model for sustainability now requires high output of sustainable production with resilience while providing even more environmental and social services.

Methodologies to measure and value ecosystem services. Several studies have related sustainability and ecosystem services. One detailed conceptual framework and typology by the Millennium Ecosystem Assessment Project (2005) involves four major outputs or services considered fundamental for natural processes and set parameters for human intervention. The shift from three services for sustainable agriculture to four ecosystem services makes it more difficult for the agriculturalist to assign priorities and use the correct measures. It would be impossible to measure all services in one experiment, so researchers need to identify key indicators for each component. This is similar in concept to measures of soil quality or water quality and will eventually lead to models that are capable of integrating many variables. Economic returns for forages or pastures depend on input costs and output values in monetary terms. Currently there is not a universally accepted way to value issues such as water, air or soil quality, an aesthetic view, or improved wildlife biodiversity. Ecological economists are developing methods to determine economic values for services based on *choice modeling*, i.e., preferences based on public surveys, and *contingent evaluation*, i.e., public preferences based on statements of willingness and amounts individuals will pay for each service.

Adapting to climate change. Biotic and abiotic stresses on plants will increase since temperatures are expected to be higher in some regions, which are expected to increase virulence of pathogens and activity of insect pests that reduce production and quality of pasture and hayland species. Lower activity of pollinators may increase

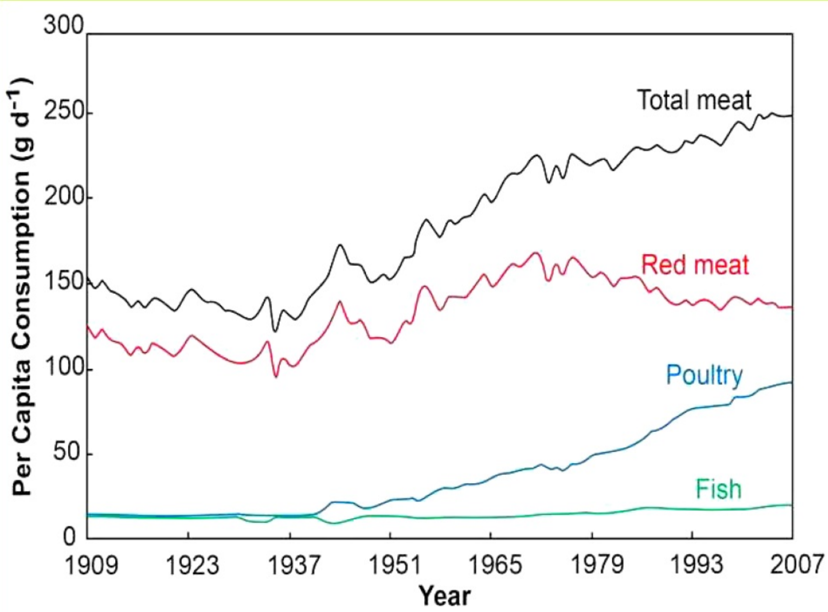

Figure 2. Consumption of meat and meat products is increasing, but that of red meat is decreasing due in part to greater health consciousness and relative cost. Data from Daniel et al. 2011. Public Health Nutrition 14:575 and USDA-ERS.

seed costs and alter food chains for wildlife. In addition, increased year-to-year variability will require emphasis on resilience as well as sustainability as climatic conditions change. If change is relatively slow, plant and animal communities can adjust naturally, but there are many unknowns regarding the rate and magnitude of climate change. Management practices such as minimum tillage for establishment, legumes in rotations for nitrogen fixation, and grazing to harvest the forage, perhaps even to time of animal harvest, will help reduce use of fossil fuels and CO_2 emissions. Manure management on pastures will be a priority for efficient use, and good nutrition of ruminants will reduce methane production. Other practices will save fuel costs, help sequester and retain carbon in the soil, and reduce labor costs. Adding forages as winter cover in crop rotations will reduce soil loss, improve water quality, and provide wildlife habitat.

Water quality and water supplies. There are many demands in the U.S. for available, sustainable clean water, with agriculture being a significant user. Growth of cities and communities will increase demand for dependable supplies that are free of sediment, pharmaceuticals, micro-organisms, and other contaminants, many of which come from non-point sources. Simultaneously, predicted climate change will place even more pressure on soil conservation and practices to reduce flooding and restore wetlands. As major aquifers and other sources are reduced, some land will revert to grasslands for animal or biofuel production. The roles and management of sensitive landscape positions will increase, as will watershed "cooperatives" that allow rural and urban citizens to address water quality and other problems at landscape levels instead of the field or farm level. Restoring perennial forages and pastures into rotations and cropping systems may best mitigate these changes.

Energy issues and biofuels. In contrast to use of food and feed crops such as corn or soybeans, perennial grasses are preferred sources for direct combustion or biological conversion of cellulose for useful forms. Less fossil fuel energy is needed to maintain perennial crops, making them more efficient based on input/output energy balances. In addition, perennial crops conserve soil year round, improve soil hydraulic properties, and can sequester large amounts of CO_2 equivalents into soil organic matter. Wildlife benefits will likely depend on when the crop is harvested mechanically and whether non-harvested patches are retained. Most biofuel grasses do not fit short-term rotations, but may be very suitable and/or preferred sites for manure applications.

Changing food consumption patterns. Obesity of U.S. citizens is increasingly leading to policies and educational efforts to mitigate this trend. Fruits and vegetables, low-fat meats and milk, and substitutes for some dairy products are being encouraged. There is movement toward more "natural" and organically produced food, including meat and milk, which rely heavily on forage and pasture use. Consumption of beef and milk, which depend largely on pastures, hay, and silage, is decreasing (fig. 2). Conversely, grass-finished beef is considered by some to be healthier, and demand for "healthy beef" may require extended time on pasture and stored forage (versus time on pasture for grain-fed livestock) before animals are harvested. This is due to animal maturation and the added time for marbling to occur when pasture-raised, therefore producing meat with desired market tenderness. Additional time on pasture will affect manure management and reduce odors often associated with confined livestock. Consumer demand for grass-fed beef and pasture-based milk production will likely grow. Thus, an increase in area used for pasture and hayland is anticipated.

Summary and Conclusions

Current approaches have served the agency well as agriculture has developed to meet food needs while conserving soil and water resources. Now a wider range of ecosystem services is expected. Each review of the CEAP assessment suggested the need for comprehensive models for handling large databases needed for effective planning and assessment of the multiple functions from pastures and harvested forages. Information from models will assist in planning conservation practices and determining variables to monitor while the practice is operational. Cost-benefit analyses from models would help prioritize programs, generate public support, and guide optimum solutions.

Monitoring of ecosystem benefits will aid USDA and NRCS by adding experience, understanding the educational needs and value of adaptive management, identifying research needs, determining the collective value of practice lifespan, improving cost-effectiveness, and documenting fiscal responsibility.

More research needs to be long-term, probably for more than 10 years. A few comprehensive, long-term experiments are needed at strategic locations to form a national framework that integrates cropland, woodland, and forest land into the farm and landscape effort. The recent development of a Long-Term Agroecosystem Research Network (LTAR) by the USDA is a step in this direction. The purpose of the network is to address questions related to the condition, trends, sustainability, and resilience of agricultural systems and resources on large scales of space and time.

One possible approach would be to pilot community efforts to set realistic goals and estimate values for the blend of ecosystem services expected at a larger scale. These values will likely differ from location to location. Then, goals of each landowner can be quantifiably used to estimate their contribution to the whole. The collective worth of an installed practice will be well beyond the incentive the landowner receives. The return value of all services needs to be communicated to policy makers and the public.

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The Conservation Effects Assessment Project (CEAP) is a multi-agency effort to build the science base for conservation policy and program development, and help farmers and ranchers make more informed conservation choices.

The CEAP Grazing Lands national assessment is designed to quantify the environmental effects of conservation practices on U.S. non-Federal grazing lands. The 584 million acres of non-Federal grazing lands in the contiguous 48 states are composed of 409 million acres of rangeland, 119 million acres of pastureland, and 56 million acres of grazed forest land.

Development of CEAP Grazing Lands processes and findings must address a number of unique challenges that are typically not present on croplands at management scales. Grazing lands typically have more diversity in climate (especially precipitation), soils, and topography than does cropland. Management practices and their effects are less precise and less well-defined, making the results of specific studies more difficult to extrapolate. There are three scales of investigation for CEAP Grazing Lands. Ecological sites will be used to stratify assessments at all three levels for the rangeland portion.

This Conservation Insight was developed by Dr. C. Jerry Nelson, Curators' Professor Emeritus, Plant Sciences, University of Missouri. It is summarized from: Nelson, C. J. 2012. Synthesis and Perspectives. Chapter 6, pp. 315-334. In: C. J. Nelson (ed.) 2012. Conservation Outcomes from Pastureland and Hayland Practices: Assessment, Recommendations, and Knowledge Gaps. Allen Press, Lawrence, KS.

For more information:

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/ceap/?cid=stelprdb1080581