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Social Understandings and Expectations: Agricultural Management and Conservation of Soil and Water Resources in the United States

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Social understandings of humans, their relationships with the land, and how they value and manage soil and water resources are built on the sciences of sociology, anthropology, political science, psychology, and economics. The "sociological imagination," of C. Wright Mills views the social nature of humans and their daily experiences from many perspectives and attempts to reconcile the two abstract concepts of the individual and society so as to see what *is* real and what *could become* real (Mills 1959; Crossman 2020). As we look at soil and water conservation challenges over the decades, seeing what is real—increased agricultural productivity concurrent with increased soil erosion, water degradation, and compromised ecosystem integrity—provides necessary feedback for changing the social narrative to what could become real—healthy soils, quality water, and resilient ecosystems alongside improved agricultural productivity and profitability.

Social understandings of agriculture are built on analyses of historical and current events as well as future expectations. Human narratives are drawn from individual knowledge and experiences, values, social norms, and worldviews in the context of social and economic structures and environmental conditions.

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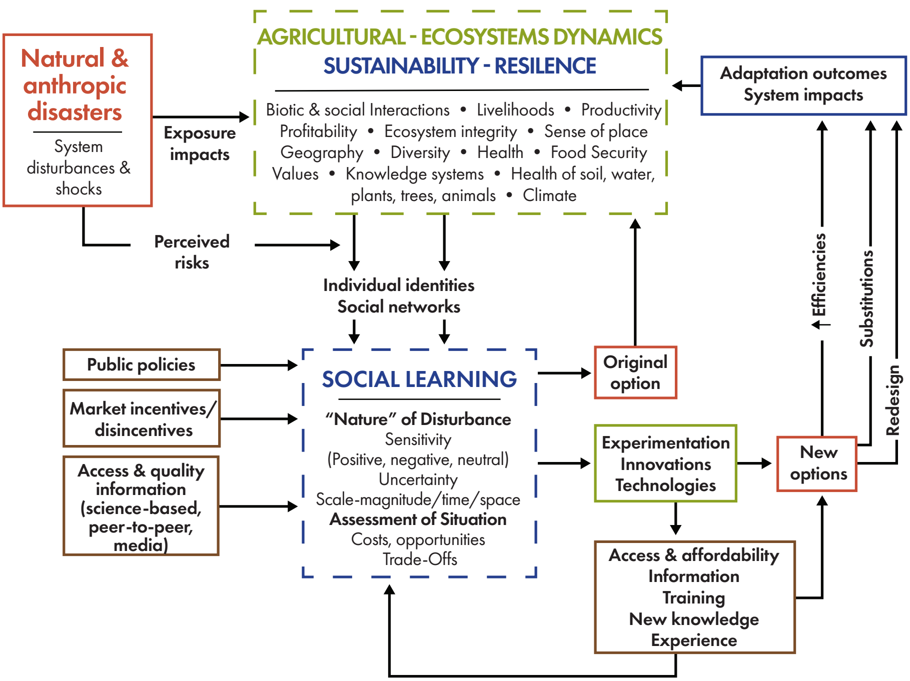
The transitions from farming to raise one's own food and clothing to a commercial enterprise with the purpose of securing a profit and livelihood to the sustainable coproduction of productivity, livelihoods, and ecosystem integrity are phenomena that have transformed land management over the history of the United States (Warren 1913; USDA 1948; Chapin III et al. 2009; Hatfield and Morton 2013; Olson et al. 2017). Social-economic-environmental transitions and transformations are often catalyzed by natural and anthropic disasters—system disturbance and shocks that alter agricultural systems; human learning, beliefs, perceptions, and behaviors; and the ecosystem itself (figure 1). The ruined livelihoods and soil erosion crisis from which the Soil and Water Conservation Society was born began with a major system disturbance, a natural climate event—drought—fueled by anthropic farming practices that compromised the ecology and productivity of the Great Plains of the United

Figure 1

Agricultural-ecosystem relationships are dynamic, nonlinear, and continuously changing over time and space. Human capacities for social learning are influenced by perceived risks from natural and anthropic system disturbances and the internal and external resources available to experiment, innovate, find new options, and adapt in ways that lead to desired sustainability and resilience outcomes in agricultural-ecosystems.



States and brought disaster. Today the 1930s Dust Bowl serves as a historical reference point and catalyst for how soil, water, and agricultural ecosystems are viewed, valued, and managed by humans and society.

The Farmer and Production Agriculture

One primary function of soil has dominated human history: its capacity to grow plants for food, clothing, and energy. Suitability of the soil to perform crop production has influenced US settlement patterns, the price of land, soil classification and functional uses, and farm management education (Warren 1913; Hatfield and Morton 2013; Olson and Morton 2016). The science of managing the soil and the training of farmers to increase practical agricultural knowledge and skills were the genesis of the land grant university system funded by Morrill Acts of 1862 and 1890. The University of Illinois at Urbana–Champaign dedicated Davenport Hall on May 21, 1901, with President Andrew S. Draper's quote inscribed over the front of the building, "The wealth of Illinois is in her soil and her strength lies in its intelligent development." The classic college Bailey series textbook, *Soils, Their Properties and Management*, published in 1909 and used at The Ohio State University, links soil formation to food production before launching into 764 pages of soil formation, structure, moisture control, acidity, amendments, tillage, and irrigation. The editor explains, the "debris of rock and plant residue that has accumulated through the centuries of struggle is the arable soil from which man obtains his bread" (Lyon et al. 1909).

Turn-of-the-century agricultural education curricula were designed to move farming from subsistence to a profitable occupation, a commercial business enterprise that generated surplus products for off-farm sales. The preface of the 1913 Bailey series on *Farm Management* describes the course as, "the science of the organization and management of a farm enterprise for the purpose of securing the greatest continuous profit" (Warren 1913). The first chapter of the textbook poses the question, "Shall I be a farmer?" It then elaborates on the personal characteristics desirable for a successful farmer: business man, mechanic, naturalist, and skilled laborer; and states clearly this is not an occupation for inefficient people (Warren 1913). These early themes, the farm as a business that makes a profit and the need for the farmer to be a naturalist who by observation of plants, animals, and the land acquires experiential knowledge and combines it with scientific investigation, run deeply through modern US agriculture.

Fifty years later, in the preface to the United States Department of Agriculture's *Grass, The Yearbook of Agriculture 1948*, Secretary of Agriculture Clinton Anderson reaffirmed the importance of the farm as a profitable livelihood: "To the farmer, security means year-to-year and generation-to-generation assurance that he can use his land as it should be used, free from fear of boom or bust; that he will have a fair market for the products of his soil and toil; and that he will get the amenities that he earns. So that he can serve community and country" (USDA 1948).

Although focusing on farm profitability, Secretary Anderson observed, it is time to give less emphasis "…to commodities likely to produce surpluses and instead direct more attention to practices designed to sustain the productivity of our soils" (USDA 1948). Thus, the *Grass Yearbook* served as a public marker for peacetime achievements in agricultural production post-World War II *and* an acknowledgement of the "extraordinary burden on the land" that cultivated crops place on soil and water resources. The authors called for a more balanced agriculture or permanence in farming systems through land use practices that revolve around a diversity of grasses, legumes, and livestock farming.

The concept of "permanence in farming systems" was a precursor to the language of "sustainability" and the increasingly urgent calls from scientists, practitioners, and farmers of the necessity to learn from the past and to use grass as a tool against floods, to guard water supplies, and replenish soils. It would be many years before "sustainability" in agricultural production systems became a central research concept that biophysical and social scientists attempted to measure. The General Assembly of the United Nations in 1983 created the World Commission on the Environment and Development and raised global awareness of critical food security and environmental issues associated with population growth, poverty, gender inequity, and wealth distribution that limit economic and social development (WCED 1987). Known as the Brundtland Report (1987), the Commission documented past successes and failures, defined sustainable development, and called for international cooperation and policies to address sustainability that rebalance the "interlocking crises" of human-ecosystem relationships in agriculture, energy, and trade sectors with environment, social, and economic concerns (WCED 1987).

Despite this report, many farmers, agricultural industries, and their value chains continued to view sustainability as a novel, unresolved, and contested concept. It was not until 2010 and the National Academy of Sciences volume, *Towards Sustainable Agricultural Systems in the 21st Century*, that the parameters of sustainable agriculture (human food, feed, fiber, and energy; environmental quality and the resource base; economic viability of agriculture; and quality of life for farmers, farm workers, and society) were again explicitly delineated (NRC 2010) and received broader acceptance by the US agricultural sector.

The framing of farming as an occupation; cyclical natural and anthropic conditions; rare system disturbances and disasters and their interactions and impacts on productivity, soil, water, and other ecosystem resources; and the modernization of US agriculture are the scaffolding that social scientists use to decode and make sense of when, how, and why farmers manage and adapt (or not) to changing conditions. Areas of research encompass individual perspectives, values, social identities, and decision making and structural and institutional arrangements that affect public policies and programs, markets, and incentives/disincentives that influence land use priorities and practices. Farmer interviews and surveys of cropping systems—perceptions of how to best manage soil and water resources—date back to the late 1970s (Davis 1977; Batie 1982; Nowak 1983, 1987; van Es 1984; Swanson et al. 1986; Kraft et al. 1989; Romig et al. 1995; Walter 1997; Coughenour and Chamala 2000). While the social sciences are increasingly funded to investigate, hypothesize, test, and reformulate models that might describe, explore, and explain agricultural-ecosystem complexity, gaps in our knowledge remain.

Social Science Research on Agriculture and Conservation

Since the establishment of the federal Soil Conservation Service in the 1930s, efforts that encourage landowners to adopt soil conservation practices on privately owned agricultural lands have been an ongoing challenge (USDA 1948; Hatfield and Morton 2013; Prokopy et al. 2019). Social science research on patterns of human behaviors, social relations, language, societies and cultures, values, and beliefs encompass a wide variety of qualitative and quantitative methodologies ranging from ethnographic (long-term field work), historical, comparative, and empirical study by observation, interviews, experimentation, systematic analyses, and cross-sectional and longitudinal survey work. The Rural Sociological Society, founded in 1937, initiated and continues to conduct research examining rural life and livelihoods, agriculture and food systems, soil and water conservation, environmental conditions, community and organizational structures, demography, and adoption and diffusion of technologies.

Agricultural research on soil and water conservation practices in the 1950s and 1960s established the effectiveness of a variety of new technologies. Conservation tillage (no-till, strip-till, ridge-till, zone-till, mulch-till, deep tillage, and seasonal residue management) continues to be accepted as an effective method for reduction of cropland soil erosion by wind and water (Reeder and Westermann 2006) and for storage, retention, and sequestration of soil organic carbon (Olson and Al-Kaisi 2015). However, documented research on the scientific effectiveness of conservation practices does not necessarily translate into landowner implementation of these technologies. There was (and is today) a need to understand what farmers are thinking, how they view and value conservation, and factors that influence decisions to move (or not) to different systems of land management.

In the 1950s, rural sociologist C. Milton Coughenour became one of the first to explore why farmers continued their "plow culture" of planting crops in a finely tilled seedbed rather than planting crops in untilled or minimally tilled ground. He and other sociologists developed and tested theories of decision making, the processes of diffusion of new agricultural innovations, and the role of "change" agents in the sociocultural revolution in cropping agriculture (Coughenour and Chamala 2000). They discovered that this new agriculture represented new knowledge and understandings of soils, the environment, the biology and ecology of plants and pests, and their interactions—and that new learning needed to take place for farmers to change their current system (Coughenour and Chamala 2000). No-till cropping systems were found on 37% of US cropland in 1998, and an almost identical rate (37.5%) was found in 2012 in the upper Midwest Corn Belt, despite significant public federal and state dollars invested in technical assistance and financial cost sharing (Comito et al. 2012; Morton et al. 2015).

Changes in agricultural practices to address impaired water resources from field and off-farm nitrogen and phosphorus runoff into neighboring streams have similarly been elusive despite high profile hypoxia research, US Environmental Protection Agency impaired water designations, and media reporting (Comito et al. 2012). Ribaudo and Gottlieb (2011) report about 35% of all US crop acres receiving nitrogen follow all the best management practices to reduce off-field nitrogen losses. This means almost two-thirds of fertilized crop acres are *not* being managed as effectively as they could be to reduce water impairments.

Renewed research on cover crops is finding this practice addresses a multitude of agriculture-ecological management needs: reducing soil erosion, retaining soil organic carbon, reducing water runoff, and absorbing excess crop nutrients. The Sustainable Agriculture Research and Education–Conservation Technology Information Center recently reported that cover crop acreage doubled from 2011 to 2016 (Basche and Roesch-McNally 2017). This is promising, but farmer adoption of cover crops remains low. The 2012 Census of Agriculture reports cover crop acreage on only 3.2% of US harvested cropland, and a 2012 survey of Midwest corn-soybean farmers finds only 6% of acreage planted to cover crops (Morton et al. 2015). **The need to understand social and human factors within agricultural-ecosystem dynamics has never been greater. There is a need for both theory and data to theorize, develop, and**

test models that better represent the complexity of human-natural relationships in agriculture.

Public and private organizations and labs, including the land grant universities and USDA Agricultural Research Service, have invested heavily in agricultural, climate, and biophysical sciences to increase knowledge about soil, water, crop physiology, hybridization, insects and disease, crop management, weed control, engineering, and innovations in equipment and other technologies. However, it was not until the early 2000s that federal government grant opportunities emphasized inter- and transdisciplinary science proposals that integrate social sciences with the agricultural biophysical sciences to address coupled human-natural agricultural systems (Prokopy 2011; Eigenbrode et al. 2014).

Simultaneously during this period, ecological scientists accelerated efforts to establish principles of the earth's ecosystems and began to construct system models that included humans and their societies (Jackson et al. 2010; Miller et al. 2012). Halle and Fattorini (2004), in *Advances in Restoration Ecology*, write, "…restoring lost systems must include humans; otherwise, the restored habitats will soon be lost again, since the very reason for the initial loss has not changed…" Humans are the "black box" that social scientists are working at unpacking (McCown 2005; Dunlap 2008). Halle and Fattorini (2004) call for human-natural systems conceptual frameworks that recognize human learning as part of the system. Further, they note that lack of good theory hinders the capacity of scientists to solve system-specific problems.

What Do We Know about Adoption of Agricultural Conservation Practices?

Social scientists use three approaches—qualitative, quantitative, and mixed methods—to develop and test theories about human behavior, social relations, and structures in agriculture. Depending on the questions of interest, prior evidence, and the complexity of human-natural systems under investigation, both inductive (observational, hypothesis-free) and deductive (standard hypothesizing) approaches are utilized.

Prokopy (2011) elaborates the uses of these approaches and their complementarity in mixed research design in the *Journal of Soil and Water Conservation* (JSWC) paper "Agricultural Human Dimension Research: The Role of Qualitative Research Methods." Inductive approaches can identify emerging concepts and events, help define research questions and relevant hypotheses, and ground-truth models that may be statistically significant but not realistically represent the phenomena that exist (Ranjan et al. 2019). A variety of paradigms, including interpretivism, phenomenology, and constructivism, utilize qualitative data such as interviews, observations, and archival materials.

"Meaning" is considered by many social scientists as socially constructed by individuals and their societies. Thus, qualitative data are particularly useful in decoding language, shared meanings, and the multiple belief systems and realities held by humans.

Deductive research, represented by hypothesis testing using quantitative methods such as surveys, seeks to uncover key variables or factors that significantly influence or predict specific outcomes. Survey methodologies have been used to examine farmer and landowner attitudes and opinions; production practices and conservation behaviors; motivations for how lands are managed; perceptions of soil and water management; farmer decision making; and how farmer identities influence soil and water conservation practices (Dillman 2000; Lubell et al. 2013; Arbuckle et al. 2015, 2017; Weber and McCann 2015; Morton et al. 2017).

The JSWC has published two classic papers that summarize the quantitative social science literature of the last 35 years on adoption of agricultural conservation practices (Prokopy et al. 2008; Prokopy et al. 2019). These papers identify several key trends that are critical for benchmarking current knowledge and guiding future social science research. Both 2008 and 2019 analyses reveal that "few independent variables have a consistent statistically significant relationship with adoption" of agricultural conservation practices (Prokopy et al. 2019). Further, in the 2019 review of 92 studies, more than three-quarters of the variables hypothesized were not statistically significant. Those factors most frequently reported significant and positively associated with adoption of conservation practices were self-identified stewardship ethic, attitudes toward the environment, awareness of a program (and positive attitudes towards the specific program), previous adoption of new practices, seeking and using information, erodible lands, larger farm size, higher levels of income and formal education, expectations of positive yields, and marketing arrangements (Prokopy et al. 2019).

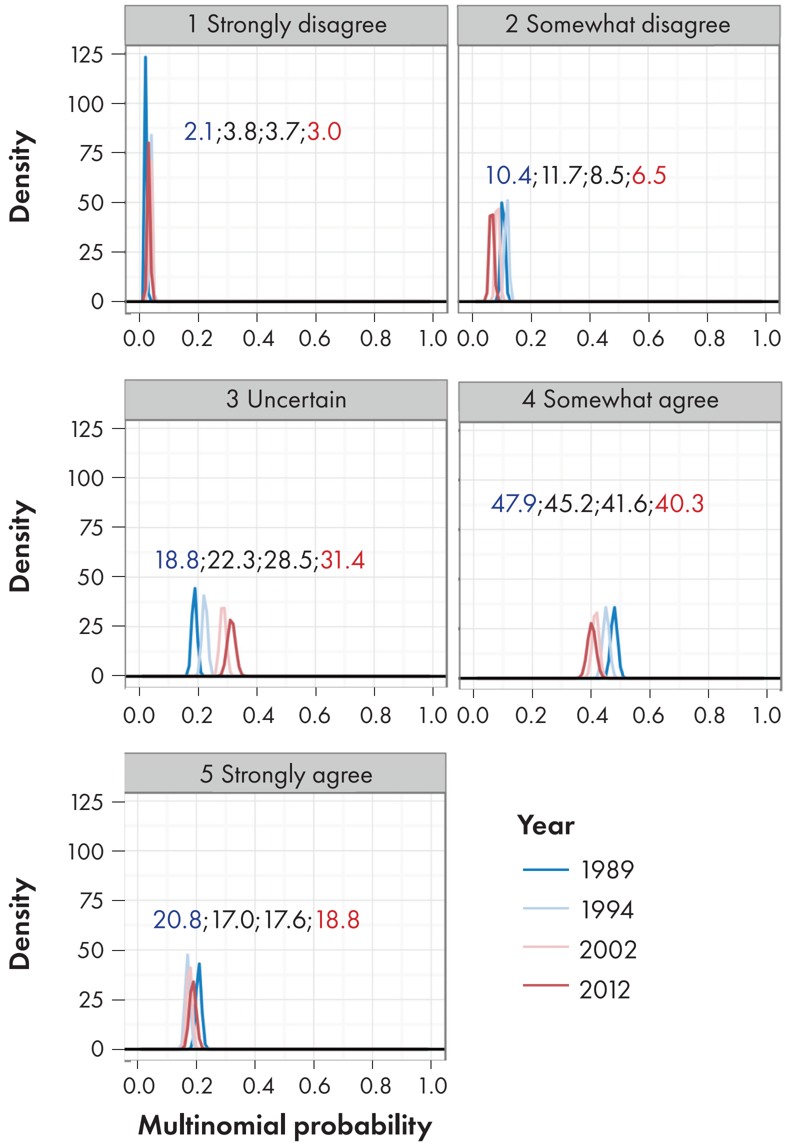
Although a number of studies applied current social science theories (e.g., attitudes toward behaviors, theory of planned behavior, values-beliefs-norms, and adoption-diffusion of innovations) to develop and test hypotheses, one-third did not use any theory in their research (Prokopy et al. 2019). More critical is that current theories are rather narrow in scope and do not represent well the complexity of individual and structural factors within human-natural systems relationships.

Looking Toward the Future

Farmers are increasingly uncertain about whether increased use of sustainable farming practices will help maintain natural resources, such as soil and water (figure 2). Although surveys of Iowa farmers show most farmers over

Figure 2

Farmer uncertainty in the belief that, "increased use of sustainable farming practices would help maintain our natural resources" (1989 to 2012) has almost doubled over a 23-year period. Data below are from the Iowa Farmer and Rural Life Poll longitudinal survey asking whether farmers "strongly disagree, somewhat disagree, are uncertain, somewhat agree, or strongly agree" with this statement. Adapted from Morton et al. (2013), including unpublished 2012 data.



a 23 year period agreed or strongly agreed that sustainable farming practices would help maintain our natural resources (Morton et al. 2013), an increasing number seem uncertain: 18.8% of farmers in 1989 were likely to be uncertain; by 2002, 28.5% were likely to be uncertain; and by 2012, almost one-third were likely to be uncertain.

What does this increasing uncertainty mean for the future of soil and water conservation in agricultural systems? Does increasing uncertainty suggest that new experiences with increasingly variable and extreme weather events, or accelerated rates of on-farm soil erosion, and/or disruptions in markets are shifting perceptions of sustainable farming practices and their effectiveness? Farmers have always made decisions in highly insecure and unstable conditions (Nieuwoudt 1972) and face many kinds of risk: production risks, price risks, and technology risks (Hamsa and Veerabhadrappa 2017). Public policies, insurance products, and expert advice have traditionally depended on economic measures of risk and complex models that estimate risk and probabilities of outcomes. These have been critical tools in helping farmers manage risk. Risk can be measured, but the uncertainties that drive risk cannot be measured or estimated. No amount of mathematics or technical adjustments change the fact that we are not able to know with certainty the future (Davidson 2010; Taleb 2014; Hamsa and Veerahadrappa 2017).

Are the uncertainties increasing in ways and at rates that make it more difficult for farmers to assess risk, evaluate their options, and make decisions? According to the Fourth National Climate Assessment, "The earth's climate is now changing faster than at any point in the history of modern civilization," and change is projected to intensify in the future (US NCA 2018). Rising temperatures, extreme heat, drought, wildfire on rangelands, and heavy downpours are expected to occur more frequently and increasingly disrupt US agricultural productivity (US NCA 2018). Climate is not the only uncertainty disrupting agriculture. The 2019 to 2020 coronavirus pandemic up-ended agricultural markets, food distribution systems, and food security in the United States and worldwide, leading to chaotic, unpredictable chain reactions (Torero 2020). Nature is nonlinear. The odds and impacts of rare events cannot be accurately computed due to lack of sufficient prior data, e.g., we have more data on 5 year floods than on 100 or 500 year floods (Taleb 2014), and we've never had a global pandemic of this magnitude before (Torero 2020).

Increasing natural and anthropic disasters and rates of system disturbance and shocks are exposing agriculture, soil, water, and Earth's ecological systems to unprecedented system-wide uncertainties (figure 1) (US NCA 2018). There is a need to better understand human internal perceptions of these events and external factors, such as social networks, public policies, market incentives, and access to science-based as well as peer-to-peer information, that influence the social meanings assigned to uncertainties and associated risks. What are the social learning processes that farmers are using to deal with uncertainty and make decisions? What factors dominate reevaluation of current practices and willingness to seek new options to address uncertainties and perceived risks? How are they deciding to hold steady (stick with original options) or adapt by increasing efficiencies, substituting technologies and practices and/or redesigning their farm systems (Morton et al. 2015; Pretty 2018)? When uncertainty is large in the system, is this an opportunity for innovation and learning to occur and a willingness to change? Or does the uncertainty at some threshold paralyze decision making and become a barrier to change and innovation?

Cultivated ecosystems cover more than 25% of the earth's land surface and "as much as six times more water is held in reservoirs than flows in natural river channels" (Walker and Salt 2006). Although climate change is one of the most prominent threats to our planet, water scarcity, poor water quality, degraded dryland and loss of wetland ecosystems, and overharvesting of marine fisheries already compromise the earth's ecosystems. Addressing changing climates, food security, commodity transport and national security associated with river and lake navigation, and water quality and supply will require new knowledge and new approaches to managing soil and water resources. **Key attributes of the future will be episodic change, unpredictability, increased uncertainty, conflicting social values and interests about land and water uses, and contested views about managing the earth's resources** (Holling 1996; Taleb 2014; Olson and Morton 2016; Pretty 2018).

Two concepts, sustainability and resilience, are front and center as humans reimagine their futures and seek solutions. Resilience assumes that change will occur and that biophysical and human systems will attempt to adapt. If successful, the system has resilience. "The measurement of resilience is the magnitude of the disturbance that can be absorbed before the system changes it structure... (Holling 1996)." What is the magnitude of disturbance an agricultural ecosystem can endure before it tips over into a different kind of system? Should resilience always be the goal or should we be embracing randomness, uncertainty, and volatility (Davidson 2010)? (This has been termed "antifragility." Taleb [2014] defines antifragile as being "beyond" resilience and robustness. Resilient means resistant to shocks and stays the same. Antifragile is the property of change in all natural and complex systems that have survived and thrived under conditions of randomness and uncertainty.) What roles will humans play in slowing or accelerating change and/or adapting to new conditions? These are human-society questions that can only be answered when biophysical and social sciences integrate knowledge, theories, and data in the search for new knowledge and solutions.

There is an urgent need for new models of human-natural systems and the integration of sciences with many kinds of disciplinary knowledge along with practitioners', landowners', and managers' experiences and knowledge. Figure 1 illustrates a conceptual framework that places human social learning as a key variable in responding to the uncertainties of system shocks and disturbances and capacities to experiment and evaluate technologies, innovate, and adopt new ways of thinking to find new options that could improve the resilience of agricultural-ecosystems and sustain soil and water resources into the future.

Agriculture should not be viewed as a "threat" to soil and water resources but rather a sector of human activity that is essential, whose future practices humans can shape (Kareiva 2011). The research society choses to invest in is value driven. If scientists, farmers, consumers, agribusiness, and governing agencies are to move toward a multifunctional agriculture that provides individual and societal benefits, we must talk with each other to learn what we value; we must together negotiate goals and actions that sustain society and increase capacities to thrive under the unexpected and future uncertainties.

Resources to Learn More

- The Farmer's Decision: Balancing Successful Agriculture Production with Environment Quality. 2005. Edited by Jerry Hatfield. Ankeny, IA: Soil and Water Conservation Society.
- Resilience Thinking: Sustaining Ecosystems and People in a Changing World. 2006. Brian Walker and David Salt. Washington DC: Island Press.

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