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The times they are changing: soil and water conservation in the 21st century†

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Our planet is in a never-ending natural state of flux, with perhaps the life-sustaining hydrologic system being the prime example. This system displays a seasonal rhythm, year-to-year variations, and slower changes at time scales of decades, centuries, and even longer periods. Since the dawn of civilization, humans have contributed to and influenced this natural flux. During early human settlement and the beginning of agriculture, impacts were minimal, local, and scattered, mainly in the form of rudimentary field-scale irrigation and limited water withdrawals for human consumption. Over time, as population increased and societies and technologies evolved, humans began to impact hydrology, land use, and microclimate at the watershed, basin, and regional scale. For example, during the time of Greek civilization and the Roman Empire, large portions of the Mediterranean basin were irreversibly deforested for fuel and construction material, trans-basin water diversions were made to supply growing cities with water, and agriculture was expanded to meet the demand for food (Hughes, 1975). All these actions contributed further to uncontrolled erosion and the sedimentation problems already caused by deforestation. In the 20th century such human impacts affected most continents, often at larger scales due to widespread mechanization, rapidly increasing population, and expanding metropolitan area. In addition to impacts on water supply and sedimentation, more recent impacts included emissions from industrialization, energy production, and transportation, as well as agrichemical runoff from agricultural croplands. Towards the end of the 20th century, there was little doubt that the hydrologic system, land use, and climate were changing at continental and global scales, and action was needed to reduce or slow cumulative negative impacts of human activity on our life-sustaining environment. Today, global climate change, society's unsustainable consumption of energy, increasing greenhouse gases emissions, continued deforestation, and mitigating actions to regain control of these runaway cumulative impacts have become popular topics of discussion.

Within this broad framework, specific concerns in the United States that must be recognized and addressed include current and anticipated impacts of changing climate, increased bio-energy demands, and population growth on agricultural landscapes. Climate change, only recently viewed by many as a far-away projection 30, 50 or 100 years from now, is already affecting us. Studies have shown that large regions of the United States are experiencing more frequent and more severe storm events (e.g. Groisman *et al.*, 1999; Kunkel *et al.*, 1999) and corresponding increases in runoff and streamflow (e.g. Lins and Slack, 1999; Miles *et al.*, 2000), leading to higher soil and agricultural chemical movement and transport (e.g. Phillips *et al.*, 1993; Pruski and Nearing, 2002), as well as more stream erosion, stream instability, and gully formation in susceptible areas. At the same time, climbing global energy prices and the push for energy independence and biofuels in the United States are increasing pressures to expand and intensify the production of biofuel feedstocks

while maintaining production of traditional crops and forage for food, fiber and feed (USDA-ERS, 2007). The number of biofuel plants is increasing, prices of agricultural commodities are at historically high levels, and more biofuel crops are being grown in the hope of increasing farm profitability. Marginal and erodible lands previously retired to grassland or forest are likely to be put back into production to take advantage of high prices for biofuel feedstock. The conversion of marginal and erodible lands to crop production and the intensification of production on existing acres will likely increase total runoff and soil erosion, offsite loading of pollutants, and destabilization of stream channels. Finally, population growth and urban sprawl in many parts of the United States are placing new pressures on agricultural land for conversion to suburban development (Hellerstein *et al.*, 2002). Impervious urban areas result in increased storm runoff, downstream flooding, and pollutant loads from roads, parking lots, and over-treated lawns and gardens. To maintain a productive, sustainable and environmentally sound landscape in the face of such changes in climate, hydrology, land use and demand for agricultural commodities, one has to look beyond the traditional approaches of the last century and embrace an expanded view of soil and water conservation.

Traditionally, soil erosion control measures implemented in the United States in the 20th century addressed primarily agricultural lands and focused on upland erosion control, stream stabilization, and small watershed protection and flood control. Many soil conservation measures were developed by the Soil Conservation Service in response to destructive dust storms during the Dust Bowl years in the 1930s, when a severe multi-year drought, rapidly expanding cropland, mechanized agriculture, and poor farming practices, combined with falling commodity prices during the Great Depression, exposed large regions of the central plains to catastrophic soil erosion by wind and water. Today's approach to conservation in agricultural landscapes must be much broader in scope than the original efforts by the Soil Conservation Service and the traditional watershed approach based mostly on quantification of runoff and erosion processes. A watershed approach for the 21st century should also consider (SWCS, 2007): (1) climate changes and resulting extreme erosion-causing events; (2) integrated treatment of all sediment and pollutant sources within the watershed; (3) targeting critical source areas for intensive conservation treatment; (4) hydrologic impacts of urban sprawl; (5) role and limitations of government conservation policies and programs; (6) need for an effective technical conservation support infrastructure at the implementation level; and (7) necessity of long-term financial commitments, public participation, and market driven incentives to maintain implemented conservation measures.

Specific changes that should be made include the following (SWCS, 2007):

1. Databases of climatic parameters used in runoff and soil erosion assessment tools should be updated regularly to reflect the frequency and severity of storms associated with changing climate more accurately.
2. Sediment sources taken into account should include not only the traditional upland erosion (agricultural croplands, construction sites and other disturbed areas), but also the higher potential for gully development due to intensified precipitation and concentrated flow, destabilization of existing channels due to increased runoff and more frequent floods associated with climate change and urban sprawl, and repeated grading of rural dirt roads and drainage ditches.
3. In order to use limited resources most effectively, the highest sediment and pollutant producing areas should be targeted for conservation first, rather than applying similar treatments throughout the watershed.
4. Urban sprawl and associated impervious runoff-producing areas must be accounted for in conservation efforts, as they change runoff and pollutant characteristics of receiving streams, and planned urban development, zoning, and storm runoff management should be an integral part of watershed-scale soil and water conservation efforts.
5. Government policies and subsidy programs must evolve beyond the traditional, fragmented approach addressing individual sources of runoff, sediment and related pollutants. These policies should facilitate conservation programs that are coordinated at the watershed level and that integrate upland soil conservation, targeting of critical source areas, prevention of gully erosion, stabilization and repair of stream channels, and other measures that enhance watershed functionality and reduce pollution.
6. Cost-cutting pressures have reduced the level and expertise of on-farm technical support needed to effectively implement and achieve the intended purpose of conservation programs. The technical-support infrastructure needs to be (re)built, particularly at the watershed scale; and conservationists should concentrate on providing technical assistance to farmers, land owners, and rural communities implementing conservation programs, leaving the accounting and management aspects of conservation programs to administrative staff.
7. Greater efforts are needed to increase participation by farmers, land owners, stakeholders, municipalities, and downstream water users, and to coordinate a comprehensive and effective control of runoff, soil erosion, and pollution at the watershed level that directly or indirectly benefit all involved. Such a

participatory approach provides better opportunities for the development of market driven and long-term financing schemes where downstream water users and water quality beneficiaries help defray the cost of upstream conservation efforts.

8. Additional research, long-term hydrologic monitoring of the effectiveness of soil and water conservation efforts, and development of practical conservation planning, assessment and implementation tools are all needed to improve conservation technologies, justify continued financial support, and effectively address today's soil and water conservation problems in agricultural watersheds

Current demands on agricultural lands and changes in the global hydrologic system—whether natural or due to human impacts—demand a new approach to soil and water conservation. The outlined approach should do a better job of taking into account a new balance of erosion processes, with greater risk of gully and stream erosion caused by higher runoff rates and volumes. Perhaps more importantly, however, the new approach must be based on far more effective policies and programs. Only with both of these elements in place will conservationists in the 21st century be able to effectively maintain a sustainable and productive agricultural landscape that benefits upstream producers, downstream water users, and the environment in general. Even though the above suggestions specifically target soil and water conservation in the United States, most suggestions are believed to also describe conservation needs in many other countries.

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