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LANDSCAPING THE LONG-TERM: WATER SYSTEM AND IRRIGATION RE-VISIONS FOR SUSTAINABILITY

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ABSTRACT: Water system managers may soon play a larger role in supporting riparian amenities, ecosystem and recreational values, and future agriculture. Increased pressure and opportunity arise from several changes. First, there is increasing interest in control of nonpoint-source pollution, fostered by advances in use of buffers and appreciation for their value. Second, there is increasing preference for local food, and changes in the costs of agricultural inputs and transportation. Third, the world food crisis increases pressure for greater agricultural production. Fourth, U.S. farm trends show accelerating "bifurcation" into either small operations with small or minimal sales, or increasingly large operations with a substantial share of sales. Climate change and climate impacts will directly and indirectly affect farming and riparian conditions as well as water management. The National Research Council (2010) has called for "transformative change" in U.S. agriculture, as well as incremental progress in existing farming systems, but transition may require new partnerships.
Water system managers are well qualified to support transitions, because they are technically competent, already engaged in long-term planning, and in many cases, financially capable of long-term action. The 63% of private farm land owned by small and very small operations may be critical for future production, particularly for local and regional production. Also, small operations engage in far more conservation programs than the large operations, which receive a greater portion of commodity support funding. However, the financial vulnerability of small operations increases the potential for sale and conversion out of agriculture.

More complex farming systems, higher diversity in crop rotations, and additional climate response flexibility may be needed, as well as coordination on larger scales to achieve locally tailored management with true economies. The great progress in watershed management has made clear that water is at the center of resource management, and the next step is to go beyond "integrated water resource management" to "water-focused integrated resource management". The time is ripe for creative collaboration with water at the center of resource conservation. An example will be shown.

KEY TERMS: Integrated water resource management, riparian, agriculture, transformational change

INTRODUCTION: CONVERGING ON RIPARIAN ISSUES

Water managers face serious challenges from population growth and changes in supply quantity and quality, as planners and engineers operate within increasingly complex systems. This paper will summarize some pressures which may dramatically impact riparian conditions, and directions for response if water managers can be informed and enlisted. The time of "stove-piped" management in which an agency operating in the human and physical environment can attend to only one element is overdue for change. This paper builds on previous presentations to the American Water Resources Association, and others, posted on <www.colorado.edu/ibs/eb/wiener/> as well as conventional publications, to avoid re-stating claims already advanced. It is the goal of this paper to argue that the reasons for water managers to enlarge their scope of concern are becoming stronger, and that the chances for real change in the interlinked sets of resources they work with are becoming greater and more urgent. The large set of references cited are intended to provide quick access to some of the relevant literatures, because this is a policy-oriented overview.

Two research inquiries motivate this paper. First, colleagues (Hanson et al., 2008) have studied a diverse range of farming systems from across the US to explore the techniques, technologies, timing, and information of production practices. Their reviews of U.S. farming systems and the driving forces affecting them led to a suggested re-visioning of many aspects

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of U.S. agriculture (Sassenrath et al. 2008, Hendrickson et al. 2008, and sequence of articles in Special Issue, Principles of Integrated Agricultural Systems, Vol. 223 No. 4 of Renewable Agriculture and Food Systems; Cambridge University). Subsequently, an examination of the dynamic changes in the agricultural landscape developed suggestions for designing and implementing realistic conservation goals (Sassenrath et al. 2010). The National Research Council subsequently also called for “transformational change”, beyond incremental progress in improving farming systems (2010). There is also an emerging consensus on the value of a landscape scale approach to agricultural and ecological systems (e.g. Nowak and Schnepf, Eds., 2010), for reasons ranging from the success of watershed governance models to the need to conserve riparian resources.

The other motivation arose from concern for climate impacts on western water management and improving the process and outcomes of irrigation water transfers to municipal uses, leading to riparian and agricultural issues. Inquiries led to involvement with water transfers and State sponsored processes beginning with the Arkansas Basin Water Bank Pilot Program (Wiener 2005), and the Statewide Water Supply Initiative, followed by the Interbasin Compact Committee and Basin Roundtable processes in Colorado. In 2009 at the AWRA, Wiener argued that better forms of water transfers are possible, and that there are substantial under-appreciated public interests involved, including cumulative impacts. Who is acting for what interests? This is still a vital question. Wiener and others at AWRA (2008a, 2008b) showed the profound but under-studied impact of water transfers on riparian hybrid ecology, and this remains an area in which riparian scientists and water managers, as well as the NGOs, should be more interactive. Water system managers should re-frame their missions beyond “simplicity, invisibility, and reliability”; the public is not only rate-payers – it is consumers, recreators, land users and land owners, and tax-payers. Agriculture comes to the fore in water issues because it is the largest user of both land and water, but the sector is extremely heterogeneous, and rapidly changing. Here, we explore the convergence of our work on sustaining both agricultural capacity and urban supply. The outcomes may critically affect riparian conditions and services.

PRESSURE AND OPPORTUNITY

Agriculture and the ecosystem, recreational, and amenity values provided are “at a crossroads” worldwide and in the U.S. (McIntyre, 2009, United Kingdom 2011). The following section is a condensation of a substantially referenced discussion on the context of U.S. agriculture , following the Hanson et al. 2008 collection. Serious questions involve the non-sustainability of inputs and externalities, including fertilizer imbalances and excesses, soil erosion (Pimentel and Pimentel 2008) energy uses, and economic structural and market problems. “Feeding the world” of more than 9 billion with more than 1 billion humans undernourished (Ash et al. 2010) demands “rapid transition” (Godfray et al. 2010) to better than business-as-usual (Herrerro et al. 2010). The first reaction is the idea that, “we have to feed the world”, increase exports (DeSchutter and Vanloqueren 2011), and intensify agricultural production on the remaining good land (Crop Science Society of America 2011), and hope that reduces conversion of other lands out of agriculture (U.K., 2011). Wiener (2011, 2012b) argues that we have displaced U.S. farming from better onto worse lands while hiding lost capacity by increasing inputs.

Agriculture and its water supply are already severely stressed (Bates et al. 2008), and that will be exacerbated with climate change. U.S. Western prospects for future water limitations are troubling; (Bureau of Reclamation 2011, Pederson et al. 2011) with increasing competition for less easily usable water (MacDonald et al. 2011, Cayan et al. 2010) further stressing aquatic ecosystems and society. Climate change and weather extremes impact all elements of productive capacity including pollinators and biota, soils and crops, and ecosystem services (Chen et al. 2011, Climate Change Science Program 2008 a-d; 2009; U.S. Global Change Research Program 2009), increasing global food insecurity (Hertel, 2011; Lambin and Meyfroidt, 2011; McIntyre Ed., 2009). The global context increases pressure to intensify production, in the short term.

What does all this mean for riparian conditions and buffer strips? Substantial U.S. land conversions out of farming have been accelerating in and out of urban areas (Nowak and Schnepf 2010, Lubowski et al. 2006a, 2006b), with substantial environmental consequences (Brown et al., 2005; Allen et al., 2006). The National Research Council (2010a: 57) found that prime farmland conversion (loss) averaged 400,000 A/yr from 1982-1992, but increased radically to more than 600,000 A/yr in 1992-2001. Eighty-six percent of fruits, nuts, and vegetables and also 63% of dairy are produced in or near metropolitan areas, resulting in a disproportionately high loss of land for high-value specialty crops (Esseks et al. 2009). This is loss of farming in areas valued for ecosystem services, including support of filtration and denitrification. The land is most appreciated for the amenity, recreational and ecological values which buffer strips and a more sustainable mosaic of diversity and land uses would conserve (Miller et al. 2012). Considering sales-based categories of farms, the share of sales by small farms fell by 1/3 between 1993 and 2003 alone. These farms owned 63% of the private land in agriculture, but produced only 16% of sales, while 84% of sales came from far more intensified large operations that are only 12% of the number of “farms” per se. In 1997, the percentage of farms smaller than 100 acres was 40.8% (ref). By 2007, this had risen to 48.5%. In 1997, the percentage of farms with sales lower than $10,000 was 50.7%; in 2007, this had risen to 63.9% (Hoppe and Banker 2010). The middle is being squeezed out; the small operations are at risk, especially in peri-urban areas.

The effects of degradation and loss of soil on water quality from large operations may have been underestimated, particularly where large equipment must work in narrow time slots, as observed in Iowa (Cox et al., 2011). Increases in soil loss due to increasing precipitation in high-intensity events may reverse decades of progress (Crop Science Society of America 2011, Climate Change Science Program 2008a, 2008c, Soil and Water Conservation Society 2003). Synergy of erosion with increasing rates of soil processes due to warming and changing vegetation communities is not clear; this will interact with degradation from heavy equipment, high levels of fertilization, and high uses of herbicides and pesticides, affecting soil structure, soil porosity and aeration, and microbial communities and processes (National Research Council 2010a, Gomiero et al. 2008, Patzek and Pimentel 2005). These problems especially threaten industrial farming from intensification which appears to be based on productivity gains that may not be repeatable and may not be sustainable with changes in energy, water, input, and transportation costs (e.g. Huang 2009). The extensive adoption and continuous use of glyphosate herbicide has elicited increasing resistance in weeds, resulting in commercial recommendations to increase tillage and use additional herbicides (Council on Agricultural Science and Technology 2012, Wiener 2012b). These changes risk long-term production and the environment, perhaps most in rural areas of large monocultural production.

Despite the enormous commercial power of global commodity agribusiness (Lee et al. 2011; U.K. 2011), consumers show strong preferences for local and organic foods, as seen by increases in direct sales, community supported agriculture and remarkably rapid growth in organics (Adams and Salois 2010). Consumers show high willingness to pay price premiums for organic and local foods (National Research Council 2010). Over 80% of organic food is sold in conventional markets rather than direct sales, estimated at $16.7 B in 2006 (Adams and Salois 2010). The “alternative” food market is an opportunity for supporting transitions to more sustainable, diversified, and riparian zone friendly farming.

A NEW PARADIGM EMERGING: MULTIFUNCTIONAL INTEGRATED AGROECOLOGY

Multifunctional agriculture recognizes that farming produces many externalities and outputs. The concept is applied to reduce pollution, enhance visual and amenity values, enhance landscape management, and the provision of other public goods (Zasada 2011, National Research Council 2010). This is especially useful for the peri-urban and intermediate land uses where urban expansion is often on the best farmland. “Integrated” agriculture emphasizes multi-farm and regional linking of outputs and products to capture nutrient flows and the benefits and adaptability of horizontal and vertical integration of multiple enterprises. The concept of *agroecology* also emphasizes “closing the loops” and reducing use of inputs and externalities such as pollution in local and regional processes (Ryszkowski, 2002). Designing agriculture as part of the ecology manages production for sustainability by adjustments to mimic ecological success (Magdoff 2007, Lal and Pierce,1991, Edwards et al. 1990). This increases response diversity and capacity, and decreases vulnerability. There is evidence that the productive capacity of organic agriculture can be comparable to conventional yields, after soil recovery from conventional farming, (Badgley et al. 2007), and with diversified outputs there may be net gains which may assist transition to climate-responsive land and water management (U.K. 2011, National Research Council 2010, Sassenrath et al. 2008, 2010); some of the gains may result from better management of what would otherwise be pollution sources.

For small and medium farms, the way forward may be transformative change which includes self-organization for several reasons. There may be commercial and operational advantages in locally and regionally “closing the loops” of manure and other by-products, such as use of oil-seeds for biodiesel for fuel and the by-product as livestock protein and calorie-rich feed supplement, closer coordination of feed and livestock operations and timing of finishing, increased resilience through more complex and soil-supporting multi-year crop rotations, increased resilience through increased spatial and temporal distributions of crops and critical reproductive stages when irrigation is critical (deficit irrigation), and other farming systems improvements. Economies of scale in some capital equipment and improved capacity to finance long-term improvements are potentially quite valuable for small operations facing short-term financing constraints. And, for marketing and meeting demands for local food, transformative change may involve self-organization for improved coordination of supplies, capitalization of food processing and storage, and increased involvement in community-supported agriculture as well as direct sales and local outlets. Self-fueling from oil-seeds (winter canola in Colorado is so far successful in several enterprises and seems very promising for more) is also desirable for farmer-city partnerships where climate responsive water management can provide cost-stabilized low-input renewable fuels for agriculture and city consumption for the long term while using less irrigation than corn or alfalfa at high-demand times, in more sophisticated rotations, allowing transfer of some water for municipal use, and flexible transfer in different conditions; hydro-climatology modeling in a project in progress suggests feasibility and warrants further study (Wiener 2012a). Integrated pest management also benefits from more complex agricultural landscapes (Duke 2011, Mortensen et al. 2011, Zadoks and Waibel 2000).

Water supply managers and riparian scientists working with the agricultural stakeholders and scientists can go a long way forward thinking about how to combine the long-term financial capacities and stability of urban systems with the pursuit of amenity, more sustainable local food production, and riparian ecosystem services and conservation. “Transformational change” is needed for agricultural sustainability (National Research Council 2010), and it must include integration with water supply, water quality, and ecosystemic needs. The riparian zone is the intersection of all of this.

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