COMMENTARY

Focusing the future of farming on agroecology

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Abstract

The future of humanity and how agriculture can continue to support the food and fiber needs of a burgeoning population are threatened by agriculture’s persistent negative effects on the environment. Essential natural resources that will be needed in increasingly greater capacity are being undermined by agricultural practices that continue to deplete the soil resource base, pollute freshwater and coastal estuaries needed for life support, reduce habitat to support biodiversity, and emit harmful greenhouse gases that compromise our ability to withstand changes to the climate. Solutions to these problems are available in known and increasingly well documented approaches using agroecological principles that manage food production in harmony with nature, not against it. This commentary provides a message that we should be seeking healing of our planet, not just less harm than in the past. It is an important distinction that needs to be considered for the future health of people and the planet.

1 INTRODUCTION

The Agriculture Innovation Agenda of the USDA aims at “increasing U.S. agricultural production by 40 percent while cutting the environmental footprint of U.S. agriculture in half by 2050” (USDA, 2020). This is a laudable goal that addresses two important aspects of global consequence—and a goal that would initially appear to be straightforward to pursue with all the relevant tools currently available, and soon to be in the toolbox, just with more fervor. The global human population continues to rise, and we all need sustenance daily (United Nations, 2019). Acknowledging that hunger is tied to political, cultural, and social factors, we focus this commentary on production and its association with environmental quality. Unfortunately, the past half-century of food production in the United States has increasingly been at the expense of the environment (IOM & NRC, 2015), mostly from externalizing costs of production (Buttel, 2003; Kling, 2019). To increase agricultural production by 40% using the same conventional approaches simply means that the environment and the most-vulnerable people will suffer even more. This is not a suitable choice.

Fortunately, the USDA agenda also recognizes the threat of agriculture to the environment. Clearly, there are many forms of agricultural production in the United States and around the world, and not all production systems threaten the environment as seriously as others (Scherr, 2016). Therefore, this commentary does not condemn agriculture but is intended instead to raise awareness that not all agricultural production systems are appropriate to meet the important goal of protecting environmental quality, which
must be met for us to have any chance of producing more food in the future. Our collective actions to increase production have consequences on the environment. Is it possible that apparent yield plateaus for some food crops might be from negative feedbacks from a deteriorating environment (Grassini, Eskridge, & Cassman, 2013)? Essential natural resources of soil, water, and air needed to produce food are being threatened and reduced in quality at a time when we need them the most. The balance between nature and humanity has ecological limits, and we must recognize that the natural resources we rely on to produce an abundance of food can also be diminished beyond repair (Hillel, 1992; Montgomery, 2012). For example, soil is essential for food production, but soil degradation diminishes its capacity to produce food in the future. Similar conditions can be stated for the functional roles of fresh water and clean air for our survival on this planet.

Our thesis is that achieving the stated goal of the USDA agenda will simply not be possible until we focus first on designing agricultural systems that operate in synchrony with nature and limit agriculture’s negative impacts on the environment. If we continue to place primary focus on increasing production, agriculture will continue to wreak havoc on the environment (Foley et al., 2011). In fact, food supplies may be sufficient, and the perception of food shortage is perhaps a matter of access at the global level resulting from conflicts, poverty policies, and income distribution (Baldos & Hertel, 2016), as well as controlling food waste in the United States (Schneeman & Oria, 2020). American farmers know how to produce food, and they will do it through free-market incentives, i.e., market prices. We have unending trust they will continue to do so. However, they should be ensured that markets will be designed around appropriate economic and social policies that foster environmental quality foremost. This is where USDA policies would be most helpful. Farmers need guidelines to keep them focused on production systems that are good for the environment, good for their rural communities, good for their labor force, and good for the people that consume the food they produce. Strong linkages exist among soil health as affected by management, human diet, human health, and the environment (Clark, Hill, & Tilman, 2018; Willett et al., 2019). Farmers’ choices of how they produce food, feed, fiber, and fuel need to fit within an agroecological approach that functions in tune with nature and not against it (Wanger et al., 2020). The USDA must develop rigorous policy guidelines with incentives tied to regionally appropriate agroecological approaches, because most family farmers want to farm with sustainable approaches, knowing that what they do is helping their families (i.e., profitable), is enriching the land they farm (i.e., protective of the environment), is nourishing humanity with good food (i.e., people and health oriented), and is meeting the demands of a growing human population (i.e., productive) (Steiner & Franzluebbers, 2009). Should we have to accept the corporate agri-business model developed in the mid–20th century? Should we not forge our own future based on sound ecological principles (Jackson et al., 2020)? Perhaps it will not be an easy task, but the sooner we start, the less damaged our environment will be, and there may be a chance it is not too late to actually fix our collective home (Rockström et al., 2009).

2 | THREATS TO THE ENVIRONMENT

Sustainability of production is threatened by widespread soil erosion, excess nutrient losses to the environment, loss of soil organic matter, compaction, and a variety of other insidious actions that lead to exhaustion of soil and biological resources. Soil erosion continues to be a problem facing U.S. agriculture despite huge investments and great strides that have been made (Cox, Hug, & Bruzelius, 2011).

The United States was blessed with an abundance of fresh-water resources, but unfortunately, many of these sources have been contaminated with excess chemical runoff and leaching. Nutrient runoff (primarily nitrogen and phosphorus) from agricultural lands still threatens the biotic integrity and ecosystem health of rivers (Murphy & Sprague, 2019), lakes (Michalak et al., 2013), and coastal estuaries (Kleinman et al., 2019). The hypoxia zone in the Gulf of Mexico continues to grow (Rabalais & Turner, 2019), despite the costly and extensive efforts at reducing nutrient loads throughout this vast watershed (Faust, Kröger, Moore, & Rush, 2017). Additionally, severe groundwater depletion has threatened the sustainability of irrigated agriculture (Famiglietti, 2014; Scanlon et al., 2012).

Soil compaction has become a major threat to environmental quality, with continued industrialization of agriculture using large tractors, high-capacity harvesting equipment, large land areas managed by farmers requiring multiple heavy machinery loads traversing land to get food and feed products out of the field (Lindstrom & Voorhees, 1994), and increasingly narrow planting and harvesting.

Core Ideas

- Vital natural resources to sustain agriculture are being undermined by the contemporary system.
- Solutions to manage our food and environmental dilemma require an agroecological approach.
- Our focus needs to be on healing our planet, not just doing less harm than in the past.
windows caused by climate change. Compacted soil not only threatens the productivity of a field but also negatively affects watershed infiltration and water retention capacity, causing flooding and endangering downstream communities.

Loss of soil organic matter menaces long-term productivity and leads to a vicious cycle where the need for greater external nutrient inputs in turn leads to greater nutrient losses (Cassman, Doberman, Walters, & Yang, 2003; Lal, 2020). Simplification of cropping systems and long fallow periods reduce carbon inputs and mine soil organic matter. Frequent tillage to cultivate simple rotations and maximize yield at the expense of other ecosystem services leads to the need for more tillage to temporarily improve soil tilth and to control weeds that become pervasive, leading to the downward spiral of low soil organic matter and exhaustion of soil resources (Franzluebbers et al., 2006).

Widespread and frequently used pesticides in modern agricultural systems illuminates the disconnect between agriculture and the environment. Weed populations arise because of previous practices that promoted their populations, problems that have been exacerbated with repeated chemical use tied to genetic modifications in plants (Price et al., 2011). Deleterious insect populations are filling a void resulting from the use of simple cropping systems and lack of balanced predator populations. Application of broad-spectrum pesticides reduces beneficial insects and creates further opportunities for invasive pest species to threaten agricultural operations. Loss of biological diversity on individual farms and within agricultural landscapes across larger ecoregions removes the ecological shields of resistance and competition (Schellhorn, Parry, Macfadyen, Wang, & Zalucki, 2015).

Greenhouse gas emissions from agriculture are a serious threat to the environment beyond the direct impacts to agriculture itself; they are affecting planetary health. Globally, agriculture contributes a large portion of nitrous oxide and methane emissions to the atmosphere (Johnson, Franzluebbers, Lachnicht-Weyers, & Reicosky, 2007). Loss of soil organic C contributes to CO₂ in the atmosphere, but burning of fossil fuels dominates the emission of CO₂. Agriculture has the opportunity with an ecologically based approach to help mitigate against greenhouse gas emissions by sequestering C in soil, which helps humanity in its fight against climate change but primarily benefits the health and vitality of soil itself.

Agriculture is fundamentally a C-engineered system. Carbon forms the backbone structure of all life—transcending agriculture to all human and ecological communities. Photosynthesis is the heart of the C cycle, fixing CO₂ from the atmosphere into organic molecules starting the food chain of life to which we depend on for carbohydrates to consume, to feed livestock, to harvest building materials, and to combust for fuel. Many of the environmental woes from agriculture are simply derived from how we mismanage the C cycle (Franzluebbers, 2010). Soil organic matter and resident soil microbial communities are gatekeepers for nutrients that are typically locked in soil organo-mineral complexes. It is the conservation and balanced use of soil organic matter that forms a strong foundation for agroecology (Janzen, 2006), to which we highlight as the best approach to simultaneously improve environmental quality and increase agricultural outputs. Agricultural success in the future depends on improving the environment and restoring ecological integrity. A holistic approach to food production systems will require that all agricultural stakeholders do their part to nurture the environment for future prosperity.

3 | TOWARD SOLUTIONS

Conservation agricultural approaches are as implied—both conserving of natural resources while focused on agricultural productivity. Conservation agriculture follows an agroecological approach to plant and animal production, meaning it relies on solar radiation to drive the system, closes nutrient cycles to avoid loss to the environment, maximizes infiltration of water into soil, relies on natural pest control when possible, and minimizes greenhouse gas emissions. As an umbrella, agroecological approaches recognize that ecological integrity must be maintained and that boundaries for production will be defined by climatic conditions of different regions. With this in mind, the plethora of conservation practices promoted by the USDA Natural Resources Conservation Service must become standard practices, not only aspirations. By working with USDA-ARS and land-grant universities around the country, researchers will discover even better conservation systems for a wider array of crops, including fruits and vegetables, to elevate our farm landscapes to the highest ecological and productive potential possible. Individual practices are important, but they must fit cohesively on farms, watersheds, and regions as part of a broader holistic culture of farmers and rural communities. Greater farmer adoption of sustainable agricultural systems would promote a vocational aura to attract youth and people of all ages, race, religion, gender, disability, and political beliefs. Fostering the culture of farming will place people as an integral part of a well-functioning food production system in accord with its environment and resource management.

We highlight here a few key features of ecologically oriented farming approaches. These can be called regenerative agriculture approaches (Francis, Harwood, & Parr,
since the focus is rightfully on improving agriculture’s relationship with the environment, which ultimately benefits society and its individuals.

1. **Agroecological production systems** based on product valorization balanced against ecological and socio-economic costs of inputs (Altieri, Nicholls, Henao, & Lana, 2015; Francis et al., 2003). Principles of soil health management can serve as a useful guide for the types of systems to be incentivized, such as minimizing soil disturbance, maximizing soil cover, optimizing biological diversity, and encouraging year-round growth to fix as much CO₂ from the atmosphere as possible.

2. **Managing nutrients and water effectively.** Research has shown that current rates of fertilizer N and P and irrigation could be reduced substantially while attaining high yield (Feng, Ouyang, Adeli, Read, & Jenkins, 2018; Yost et al., 2018), and with greater economic return and reduced nutrient losses (Franzluebbers & Shoemaker, 2020). Biologically based soil evaluation methods can optimize nutrient inputs, while stabilizing farm economics and fostering biodiversity. Conservation nutrient management improves soil health, allowing soil biological activity to thrive and provide essential nutrients to fruit, vegetable, grain, and forage crops. Supplemental fertilization and irrigation should be used only to fill necessary gaps.

3. **Pasture–crop rotations to foster biodiversity and build agricultural resilience.** The fastest way for soils to regain health and double the concentration of surface soil organic matter is to adopt a system of pasture–crop rotations with modern cultural techniques—not a return to widespread soil exposure with tillage (Franzluebbers, 2012). Soil health improvement and agricultural diversification will lead to systemwide improvements in nutrient cycling and pest management.

4. **Utilizing marginal agricultural landscapes for silvopasture and biofuel management.** Marginal agricultural lands are often a source of non- or underperforming agricultural operations, but they could be reliable for biofuel production (DeBolt, Campbell, Smith, Montross, & Stork, 2009). Dual-purpose bioenergy and grazing in silvopastures could achieve production, wildlife, biodiversity, and ecological benefits (Jose, Walter, & Kumar, 2017).

5. **Diversifying the agricultural landscape.** Many of our current environmental problems are a result of widespread adoption of agricultural approaches that concentrate livestock or create vast stretches of simplified cropping systems (Lemaire, Franzluebbers, Carvalho, & Dedieu, 2014). This approach finds us continually fighting battles with weather extremes, diseases, air-borne contaminants that affect human health, widespread soil degradation, and nutrient runoff and chemical contamination of water bodies. The focus on just a few cash crops also affects the food that we eat and ultimately, the health and wellness of the nation (Putnam, Allshouse, & Kantor, 2002).

Contemporary, industrialized agriculture was developed decades ago, but we should question whether it is acceptable or desirable today, knowing the numerous impacts this approach has on human health, environmental quality, and long-term sustainability of agroecosystems. Basic and applied research should focus on how agriculture can holistically sustain life, not harm it. Market incentives will be needed, but government’s role is essential to reinforce our values for all forms of life, whether that is human, plant, faunal, or microbial.

Conservation and agroecological approaches must be the norm to achieve significant improvement in the environment and still produce a bountiful, healthy, and diverse harvest. Existing USDA conservation practices already provide a menu of options for how to design better agricultural systems to protect the environment, that are productive, that are profitable, and that serve the people.

**4 | THE FUTURE OF ECOLOGICALLY BASED FARMING: IT’S NOT A FANTASY—IT’S A NECESSITY**

The general trend of agriculture in the past half-century has been dominated by corporate influences, and unfortunately, farmers have not been in the driver’s seat during these changes. Instead, farmers have been forced to fit the model of an increasingly corporate and culture-less few. When farmers did not fit the model, they were pushed aside. Agricultural landscapes and the environment in the United States have been in decline for decades, but we cannot put this off any longer—we need to put culture back into agriculture. Leadership is needed, and we appreciate that USDA is open for having this discussion. Considering our increasing vulnerability to climate change, now is the time to shift our emphasis to agroecology.

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REFERENCES

Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015). Agroecology and the design of climate change-resilient farming systems. *Agronomy for Sustainable Development*, 35, 869–890. https://doi.org/10.1007/s13593-015-0285-2

Baldos, U. L. C., & Hertel, T. W. (2016). Debunking the “new normal”: Why world food prices are expected to resume their long run downward trend. *Global Food Security*, 8, 27–38. https://doi.org/10.1016/j.gfs.2016.03.002

Buttel, F. H. (2003). Internalizing the societal costs of agricultural production. *Plant Physiology*, 133, 1656–1665. https://doi.org/10.1104/pp.103.030312

Cassman, K. G., Doberman, A., Walters, D. T., & Yang, H. (2003). Meeting cereal demand while protecting natural resources and improving environmental quality. *Annual Review of Environment and Resources*, 28, 315–358. https://doi.org/10.1146/annurev.energy.28.040202.122858

Clark, M., Hill, J., & Tilman, D. (2018). The diet, health, and environment trilemma. *Annual Review of Environment and Resources*, 43, 109–134. https://doi.org/10.1146/annurev-environ-102017-025957

Cox, C., Hug, A., & Bruzelius, N. (2011). *Losing ground*. Environmental Working Group. Retrieved from https://static.ewg.org/reports/Losingground_of_0516.pdf

DeBolt, S., Campbell, J. E., Smith, R., Montross, M., & Stork, J. (2009). *Chapter 12—Responses in sustainablesilvopasturedesignandmanagement*. Falcons in Agriculture, Ecosystems and Environment, 130, 337–342. https://doi.org/10.1016/j.agee.2009.01.012

Famiglietti, J. S. (2014). The global groundwater crisis. *Nature Climate Change*, 4, 945–948. https://doi.org/10.1038/nclimate2425

Faust, D. R., Kröger, R., Moore, M. T., & Rush, S. A. (2017). Management practices used in agricultural drainage ditches to reduce Gulf of Mexico hypoxia. *Bulletin of Environmental Contamination and Toxicology*, 100, 32–40. https://doi.org/10.1007/s00128-017-2231-2

Feng, G., Ouyang, Y., Adeli, A., Read, J., & Jenkins, J. (2018). Rainwater deficit and irrigation demand for row crops in Mississippi Blackland prairie. *Soil Science Society of America Journal*, 82, 423–435. https://doi.org/10.2136/sssaj2017.06.0190

Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., … Zaks, D. P. M. (2011). Solutions for a cultivated planet. *Nature*, 478, 337–342. https://doi.org/10.1038/nature10452

Francis, C. A., Haywood, R. R., & Parr, J. F. (1986). The potential for regenerative agriculture in the developing world. *American Journal of Alternative Agriculture*, 1, 65–74. https://doi.org/10.1017/S088918930000904

Francis, C., Lieblein, G., Giessler, S., Brelan, T. A., Creamer, N., Harwood, R., … Poincelot, R. (2003). Agroecology: The ecology of food systems. *Journal of Sustainable Agriculture*, 22, 99–118. https://doi.org/10.1300/J064v22n03_10

Franzluebbers, A. J. (2010). Will we allow soil carbon to feed our needs? *Carbon Management*, 1, 237–251. https://doi.org/10.4155/cmt.10.25

Franzluebbers, A. J. (2012). Grass roots of soil carbon sequestration. *Carbon Management*, 3, 9–11. https://doi.org/10.4155/cmt.11.73

Franzluebbers, A. J., Follett, R. F., Johnson, J. M. F., Liebigs, M. A., Gregorich, E. G., Parkin, T. B., … Martens, D. A. (2006). Agricultural exhaust: A reason to invest in soil. *Journal of Soil and Water Conservation*, 61, 98A–101A.
Price, A. J., Balkcom, K. S., Culpepper, S. A., Kelton, J. A., Nichols, R. L., & Schomberg, H. (2011). Glyphosate-resistant Palmer amaranth: A threat to conservation tillage. *Journal of Soil and Water Conservation, 66*, 265–275. https://doi.org/10.2489/jswc.66.4.265

Putnam, J., Allshouse, J., & Kantor, L. S. (2002). U.S. per capita food supply trends: More calories, refined carbohydrates, and fats. *FoodReview, 25*(3), 2–15.

Rabalais, N. N., & Turner, R. E. (2019). Gulf of Mexico hypoxia: Past, present, and future. *Limnology and Oceanography Bulletin, 28*, 117–124. https://doi.org/10.1002/lob.10351

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F. S., Lambin, E. F., … Foley, J. A. (2009). A safe operating space for humanity. *Nature, 461*, 472–475. https://doi.org/10.1038/461472a

Scanlon, B. R., Faunt, C. C., Longuevergne, L., Reedy, R. C., Alley, W. M., McGuire, V. L., & McMahon, P. B. (2012). Groundwater depletion and sustainability of irrigation in the US High Plains and Central Valley. *Proceedings of the National Academy of Sciences of the United States of America, 109*, 9320–9325. https://doi.org/10.1073/pnas.120031109

Schellhorn, N. A., Parry, H. R., Macfadyen, S., Wang, Y., & Zalucki, M. P. (2015). Connecting scales: Achieving in-field pest control from areawide and landscape ecology studies. *Insect Science, 22*, 35–51. https://doi.org/10.1111/1744-7917.12161

Scherr, S. (2016). Transforming agriculture from threat to solution for environmental challenges. *Ecosystem Marketplace*. Retrieved from https://www.ecosystemmarketplace.com/articles/transforming-agriculture-threat-solution-environmental-challenges/

Schneeman, B.O., & Oria, M. (Eds.) (2020). *A national strategy to reduce food waste at the consumer level*. Washington, DC: Committee on a Systems Approach to Reducing Consumer Food Waste, National Academies Press.

Steiner, J. L., & Franzluebbers, A. J. (2009). Farming with grass—For people, for profit, for production, for protection. *Journal of Soil and Water Conservation, 64*, 75A–80A. https://doi.org/10.2489/jswc.64.2.75A

United Nations. (2019). *World population prospects 2019: Highlights* (ST/ESA/SER.A/423). Department of Economic and Social Affairs, Population Division. Retrieved from https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf

USDA. (2020). *USDA engages public for input on the agriculture innovation agenda* (Press Release No. 0210.20). Retrieved from https://www.usda.gov/media/press-releases/2020/04/01/usda-engages-public-input-agriculture-innovation-agenda

Wanger, T. C., DeClerck, F., Garibaldi, L. A., Ghazoul, J., Kleijn, D., Klein, A.-M., … Weisser, W. (2020). Integrating agroecological production in a robust post-2020 global biodiversity framework. *Nature Ecology & Evolution, 4*, 1150–1152. https://doi.org/10.1038/s41559-020-1262-y

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., … Murray, C. J. L. (2019). Food in the Anthropocene: The EAT-Lancet Commission on healthy diets from sustainable food systems. *The Lancet Commissions, 393*, 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4

Yost, M. A., Veum, K. S., Kitchen, N. R., Sawyer, J. E., Camberato, J. J., Carter, P. R., … Nafziger, E. D. (2018). Evaluation of the Haney Soil Health Tool for corn nitrogen recommendations across eight Midwest states. *Journal of Soil and Water Conservation, 73*, 587–592. https://doi.org/10.2489/jswc.73.5.587

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