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COMMENTARY FROM THE U.S. AGROECOLOGY SUMMIT 2023

Increasing the scope and scale of agroecology in the Northern Great Plains

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Large Scale Agroecology

Agroecology is a science, practice, and movement that is gaining momentum worldwide. It aims to provide local, stable, and diverse diets through diversified, resilient, and sustainable agricultural practices (Ewert et al. 2023). However, agroecology seeks to address food systems issues by replacing large-scale commodity-based agriculture with something very different. Agroecology is typically discussed within the scope and scale of smallholder farming while failing to address the issues embedded in large-scale commodity-based agriculture. While we do not take issue with an ideal system where food is produced on small farms, it does not need to exclude agroecology applied to current scales of agriculture in regions like the Northern Great Plains (NGP), where agriculture consists of spatially extensive crop and livestock farms. NGP farms have internal sustainability problems and harmful social, racial, and environmental externalities that can be addressed with agroecological principles. Despite the problems, the large scale of NGP agriculture is not likely to change much in coming decades, and so there is an imperative to apply agroecological principles at larger scales to address immediate issues. We emphasize that applying agroecological principles to large-scale farming could increase crop and forage diversity, conserve biodiversity, strengthen cross-boundary and multi-objective ecosystem management, address regional food security, and encourage co-innovation with crop and livestock producers in

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the NGP (Tittonell, 2020). If agroecologists don't address the immediate issues of NGP such as climate change adaptation and mitigation, livestock-based protein production, unequal access to nutritious food, agriautomation, and pandemic food system disruption, then we may only expect industrialized agriculture to provide short-sited profit-motivated solutions repeating a pattern of the past.

Northern Great Plains Context and Issues

The NGP covers an area of about 1,940,000 km2 and crosses five U.S. states (Nebraska, South Dakota, North Dakota, Wyoming, and Montana) and two Canadian provinces (Alberta and Saskatchewan) (Wang et al., 2016). The historical climate is semi-arid to sub-humid with long, cold winters and short, warm summers (Wang and Fang, 2009). Recent summers have become increasingly dry and hot, challenging annual small grain production in the northwestern portions of the region (Whitlock et al., 2017). European settlement beginning in the 1880s, saw the beginning of natural land cultivation and livestock introduction. Currently, about 50% of the NGP remains natural grassland and nearly 100% of the uncultivated area is grazed by large mammals, principally cattle (Hooper et al. 2005). Average farm size in the NGP states was 1,699 acres versus 322 acres in 5 adjacent states to the east of the NGP and 195 acres in 5 Eastern Seaboard states in 2021 (U. S. Department of Agriculture National Agricultural Statistics Service [USDA NASS], 2022), providing a sense of the scale difference in agriculture between regions. Since 2012, 32 million acres of previously undisturbed land, mostly along the eastern edge of the NGP, has been plowed up primarily for corn and soybean production (World Wildlife Fund, 2023). This land conversion contributes directly and indirectly to greenhouse gas (GHG) emissions, with these crops targeted for ethanol and livestock feed-lots, certainly not for local food production. Approximately 4.2% of the population in the U.S. portion of the NGP is Native American and 22% of the land is within the boundaries of Reservations where health and food security are major issues. The NGP Indigenous Peoples have a high frequency of diet related health issues including diabetes, heart disease, and chronic inflammation. The grassland ecology, agricultural context, rural demographics, and health of Indigenous Peoples of the NGP creates a stage for agroecology to be applied, albeit at a much larger scale than what agroecology tends to be focused on. We believe agroecology can offer solutions to the large agricultural issues that are often avoided by traditional agricultural research institutions (i.e. Land Grant Universities, USDA Agricultural Research Service, etc.) in the NGP.

Agroecology research can lead to solutions by drawing attention to the issues of current agriculture, quantifying the ecological and socioeconomic impacts, and offering alternative transdisciplinary approaches to commodity agriculture. In many cases the agroecological approaches may represent bridges from the industrial focus to a more ecologically driven food system. This food system would be dedicated to food production at large scales that equally emphasizes crop and livestock nutrient density, equal access to healthy food, economic equality, minimization of pollution, and conservation of biodiversity.

Alternative Agricultural Research Questions for the NGP in the Future

Traditional agricultural research in the NGP has primarily addressed the changing climate issue by focusing on breeding crops for tolerance to increased aridity: crop diversification (mostly in the form of rotational cover crops) and reduced tillage systems to improve soil moisture retention and increase resilience to drought. Livestock production research has narrowly focused on developing current popular cattle breeds to be more tolerant to heat and water shortages, but still finishing cattle in feed-lots. Research has also focused on increased infrastructure to deliver water to animals and forage crops. Agricultural research in the NGP has largely been aimed at the production of small grains (i.e. spring and winter wheat and barley) rotated with cover crops (often legumes that will fix nitrogen). These yield-centric approaches do not consider major issues in current NGP agriculture such as limited growing season precipitation, extreme heat interrupting crop and livestock growth cycles, changes to the hydrology of the region affecting livestock water and crop irrigation,

and food security and human health issues for the region. Thus, more appropriate research questions that could put the NGP on a more agroecological trajectory without a major change of agricultural scale might be:

1. How will the NGP most efficiently and sustainably contribute to feeding an increased, mostly urban, global population, while simultaneously addressing local food availability and quality?
2. Given end of century climate projections for the NGP, will crop production remain a viable option, or will new forms of agricultural land use need to be considered on cultivated lands? If climate drives a shift to even greater portions of land dedicated to livestock production without finishing in distant feed-lots, how will agroecology be employed to best accommodate this transition?
3. Can the healthcare crisis of the region be solved by focusing on food as medicine? What role can Indigenous Peoples of the NGP play in developing an indigenous knowledge informed agriculture focused on nutrition, medicine, and food security? How can the NGP food system deliver equitable access to nutritious food and honor the food sovereignty of NGP Indigenous Peoples?
4. How can NGP agriculture contribute to conservation of biodiversity in the grassland and savanna ecosystems?
5. Can agroecology as a discipline provide research to appropriately scale food production and food chain structure to be sustainable and resilient to climate, market, and pandemic extreme events?

Examples of Potential Agroecological Solutions in the NGP

NGP agriculture needs to prepare for climate change that will constrain annual crop production and force increased livestock production onto the NGP landscape (Conant et al. 2018; Whitlock et al. 2017). The energy inefficiency of finishing (fattening on corn and soybeans) NGP raised livestock in Midwest feedlots coupled with the need to produce crops for direct human consumption in the Midwest will result in livestock remaining on the range in the NGP. Vegetable-based protein for direct human consumption will be needed to determine crop choices in the Northcentral region. Protein from meat will likely be forced on to rangelands like those in the NGP as meat production in feedlots and confinement facilities decreases with cheap feed shortages and the threat of disease spillover from livestock. Global and climate related issues will challenge current institutional assumptions about irrigation and current crop and livestock species breeding for heat and drought tolerance solutions for the NGP (Shamon et al., 2022). A long history of bison on the NGP has selected for an animal much better suited for projected climates than currently exploited livestock species. Bison adapted to the NGP and coevolved with soil microbe, plant, insect, and animal communities may play an important role in NGP conservation of biodiversity (Shamon et al. 2022). Bison physiology, behavior, and efficiencies relative to water limitations, heat tolerance, resilience to extreme weather events, and general management as well as the nutritional quality of the meat produced indicate that bison should be the focus of future livestock agriculture in the NGP (Martin et al., 2021). In addition, and consistent with the place-based concept central to agroecology albeit applied at a large spatial scale, bison-based food sovereignty for native peoples (mostly engaged in livestock production) has become a logical solution to an otherwise grim future for the region (Shamon et al., 2022). The movement of agroecology in the NGP is largely centered on efforts by Indigenous People to re-establish bison in the NGP and create local meat processing facilities. Agroecology as an academic discipline can engage partnership with the native efforts to co-lead the region into a sustainable future with a new vision for agriculture. Perhaps fenced land ownership boundaries including native and non-native private and government land can be combined to create the large spaces required by bison to follow behaviors that will result in many of the goals of agroecology at NGP appropriate scales.

Much of the recent cultivation (sod-busting) that has occurred in the NGP is to grow corn and soybeans for livestock in confinement facilities and

to produce ethanol. The agricultural system results in rural depopulation, overemphasis on economic rather than ecological drivers of agriculture, increasing farm size (economies of scale), non-nutritious foods, degraded soils, pollution of air and water and loss of biodiversity. NGP research on any one of these impacts has not been addressed by traditional agriculture research institutions, and has certainly not addressed the interactions among the factors detracting from some optimum agriculture driven by agroecological principles. Agroecology-based solutions and opportunities for research may include:

1. Diversifying the crops grown in the NGP to refocus on direct production of human food with high nutrient density and on soil quality characteristics.
2. Growing crops with the intention to increase nutrient density of livestock forage and decrease reliance on medicinal inputs (antibiotics, growth supplements, etc.) (Provenza, 2018).
3. Partnering with Native American tribes to switch from cattle to bison as a more viable, culturally important livestock animal for the projected climates on the NGP.

Local Reservation-based meat processing could be a major step toward food sovereignty, allowing for increased tribal control of the local food system. Bison production of protein without reliance on GHG emitting feedlots and production of crops for the feedlots has significant potential for solving several major issues without entirely removing meat from the human diet.

NGP farms will continue to produce small grains (spring and winter wheat, barley, and the rotational cover crops which are primarily legumes, as well as oil seeds like safflower, sunflower and canola) for the next few decades. The corn and soybean extension onto the NGP is driven by contemporary economics but is shortsighted. Thus, agroecological research must prioritize creating alternative sustainable cropping systems at scale. The economies of scale will demand that current crops be produced on large scales. However, there are opportunities for the discipline of agroecology to contribute in significant ways to envisioning new approaches (Tittonell, 2020) and draw on modern technologies to reduce the scale within fields to ecologically and economically driven optima (Duff et al. 2022). Further diversification of these systems to remove summer fallow and decrease fertilizer and pesticide (including herbicide) inputs will be within the purview of agroecology research with the crucial addition of response variables, such as nutritional density, diversification and localization of markets, value added products, contributions to regional food security, and conservation of biodiversity. Scalable complexity capturing and optimizing for ecosystem services with the goals of production and conservation of biodiversity will be an important challenge for agroecology research (Duff et al. 2024). Agroecology research can help to reverse the trend of crop and livestock production requiring the hydrologic altering water delivery infrastructure needed to ameliorate increased drought and precipitation pattern changes (Laugherburger et al. 2022). Ultimately, the agroecology discipline comprised of science, practice, and movement has significant relevance at the scales at which agriculture is currently conducted.

Rationale for Increasing the Scope and Scale for Agroecology

At present, it seems that agroecology is not strategically engaged in addressing the regional realities, dynamics, challenges, and potential of large-scale NGP agriculture. While agroecology has gained a toehold through the popularization of organic and regenerative crop and livestock production, the science of agroecology to support agroecological practice and movement in the NGP is sorely lacking. The movement of agroecology in the NGP is largely centered on efforts by Indigenous People to bring bison back to the plains. If the science of agroecology does not use its privileged positionality to engage in these issues, we speculate that instead of addressing the root of these agricultural issues, agribusiness and other private tech companies will find ways to perpetuate and continue profiting from large-scale, high input, industrial agriculture. Thus, these current challenges present a pivotal opportunity for the discipline of agroecology to transform large-scale agricultural issues into large-

scale agroecology. An ideal future may target farm size reduction and may, in part, be able to accomplish that goal with modern monitoring and precision technologies. However, regions like the NGP are not likely to shift to smaller scales of agriculture on a time scale that will solve major issues. To totally commit agroecology research to small-scale farms that produce local food would ignore vast landscapes around the world. Scaling up agroecology to address large scale agricultural issues like those on the NGP will require transdisciplinary engagement at multiple scales and a commitment to co-production of participatory knowledge. In addition, agroecology must lead with the admission that, in regions like the NGP, research into agroecosystems that form bridges to ideal systems will be required to avoid marginalization of the agroecology discipline.

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