Integrating human dimensions within the LTAR Network to achieve agroecological system transformation

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On the Ground

- Agroecosystem research often focuses on biophysical processes and productivity without incorporating human dimensions research and/or stakeholder engagement.
- Connecting individual and community well-being to agro-innovation research is required for agroecological transformation to sustainable intensification.
- Long-Term Agroecosystem Research (LTAR) Network sites have historically had varied degrees of human dimensions research within their research plan; however, LTAR's human dimensions capacity has grown.
- To capitalize on this capacity, we propose a four-step framework for the LTAR Network to evolve a cohesive human dimensions strategy that brings together the social and ecological.
- Continued institutional support is required to maintain and further pursue research that will support stakeholder co-developed science that facilitates agroecosystem transformations benefiting society.

Keywords: Agroecosystems, human dimensions, stakeholder engagement, sustainable intensification, well-being.

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Introduction

Agricultural research aims to advance the production capacity and environmental quality of agriculture practices. However, by focusing on environment and production variables, the processes and outcomes of agriculture are framed in a way that does not fully capture the human dimensions of agricultural production. For example, with respect to livestock production systems and rangelands science in North America, a production-oriented paradigm grew out of concerns about early 19th century grazing impacts to soil quality and vegetation.[1] This focus on agricultural practices and ecological processes is important for understanding outcomes for biodiversity and ecosystem health, yet outcomes for people and rural communities remain out of focus. Although implications of this production-oriented ecological research shed some light on economic impacts to individual operations and to industry, recent syntheses point rangelands scholars toward sociopolitical and historical challenges and our need to understand how experiences and needs vary across a diverse range of stakeholders in terms of race, ethnicity, class, and gender.[1] As rural communities undergo major shifts in demographics, land ownership, and land use, questions about how agriculture shapes and impacts the lives and well-being of a much broader range of people must come into sharper focus.

To better understand how agriculture impacts producers, rural communities, and society, it is necessary to transform the subjects and processes of agricultural research. We define human dimensions of agroecosystems research as an interdisciplinary science that aims to understand and enhance food, fuel, and fiber agroecosystems and rural communities by integrating various social science disciplines and methods across, but not limited to, rural sociology, economics, anthropology, and geography. Effective integration of human dimensions research with natural science research has been limited due to institutional and disciplinary differences that view social and ecological processes separately, rather than as complex social-ecological systems.[2] This separation creates a gap in agricultural research, effectively undervaluing the rich and dynamic human-nature relationships that producers have with their

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land and communities. Viewing rangeland agroecosystems as complex social-ecological systems is not a new concept from a theory standpoint; however, methodologically, it has proven difficult to study.[3]

Additionally, effective integration of human dimensions research requires clear goals and objectives for social scientists and partners who should be included from the beginning of a project's design. Problem identification and research question development can become complicated for interdisciplinary collaborators when outreach and engagement are confused or conflated with applied social science. As a social phenomenon, an organization's interactions with its partners and stakeholders are a common subject of social science research. However, social scientists are sometimes asked to lead stakeholder engagement efforts for an organization, rather than study the process of engagement, its formation, characteristics, and impacts. There are important distinctions between stakeholder engagement as a practice, stakeholder engagement as a subject of research, and who should be involved in each role.

Given the challenges for effective integration of human dimensions research highlighted here, namely disciplinary differences and confusion about the appropriate role for social scientists, there is a need to document opportunities and processes for human dimensions integration when they arise. We outline the mission of a core group of scientists charged with the task to integrate human dimensions of agroecosystems research across a national research network.

The USDA-Agricultural Research Service's (USDA-ARS) Long-Term Agroecosystem Research (LTAR) Network aims to develop national strategies to promote sustainable intensification. Sustainable intensification is a three-fold task of increasing productivity, environmental quality, and rural prosperity to transform agroecosystems.[4] To do this, 18 research sites across the United States conduct coordinated research within a series of croplands and grazinglands agroecosystems (Fig. 1). The LTAR Network is focused on implementing a "common experiment" that aims to collect long-term data for comparing Business as Usual (BAU) agricultural systems to Aspirational (ASP) agricultural systems. BAU systems are "local, predominant, conventional production systems," and ASP systems are "hypothesized to advance sustainable intensification in locally appropriate ways."[5] A "common experiment" example from the Jornada LTAR site is comparing how conventional cattle genetics vs. heritage cattle genetics and other supply chain variables impact sustainable intensification goals in the southwest United States.[6] Ideally, the "common experiment" is based on knowledge about the system that is informed by stakeholders' needs, priorities, and experiences. Therefore, LTAR aims to implement stakeholder engagement strategies to evaluate the effectiveness of ASP agricultural practices over time while advancing the application and integration of the social sciences with biophysical and agroecological research.

Knowing how to increase effective and equitable stakeholder engagement is one of many goals of human dimensions research. As such, integrating human dimensions research into LTAR is an urgent priority. Changes to the USDA-ARS's LTAR Network are underway to effectively address well-being connections between agriculture and society. The creation of a Human Dimensions Working Group (HDWG) and collaborations with university researchers (e.g., University of Idaho's Transformational Agroecosystem Science Team [TAST]) represents an important early step toward improving the application and integration of the social sciences in LTAR research. In particular, the LTAR HDWG is playing a key role in developing strategies for sustainable intensification that integrate human well-being into public sector agricultural research. Their mission is being achieved by: 1) engaging stakeholders to identify and include indicators of well-being within ASP systems visioning; 2) developing methods and indicators to assess agricultural practices and trade-offs between production, environmental quality, and individual and community well-being; 3) identifying opportunities and barriers to adoption of sustainable agroecosystem management strategies; and 4) developing and delivering knowledge, tools, and products to facilitate adoption of aspirational strategies and innovations.

While this shift toward integration of human dimensions research within long-term agroecosystem research is in its infancy, there is great opportunity for LTAR to play a part in transforming our agroecosystems.[4] In this article, we begin by framing the historical scope of human dimensions research within the LTAR Network, describe the increased capacity added to the LTAR Network by the formation of the HDWG and TAST lab, and outline a research framework for enhancing the transformative impact potential of the LTAR Network and other research networks.

Historical integration of human dimensions within LTAR

Transformation of current agroecosystems to maximize the triple mission of productivity, environmental quality, and rural prosperity will require strategic, large-scale changes in society-environment interactions for which no historical analogue exists. Historically, within other long-term interdisciplinary natural resource research networks, such as the Long Term Ecological Research (LTER) Network, human dimensions research has been siloed from natural resource research, leading to a decrease in research effectiveness and impact.[7] Organizational barriers, funding constraints, infrastructure limitations, and data coordination and management issues were found to be the primary barriers to social and natural science integration within LTER.[8] The fact that the LTER Network is still working through these barriers after four decades is evidence of the complexity of integrating human dimensions and natural science research. It is strategic for the much younger LTAR Network to learn from these lessons, recognizing these barriers now, to enable the LTAR Network to address or avoid these problems where possible.

The LTAR Network's integration of human dimensions research has evolved since its creation in 2012 (Fig. 2). The

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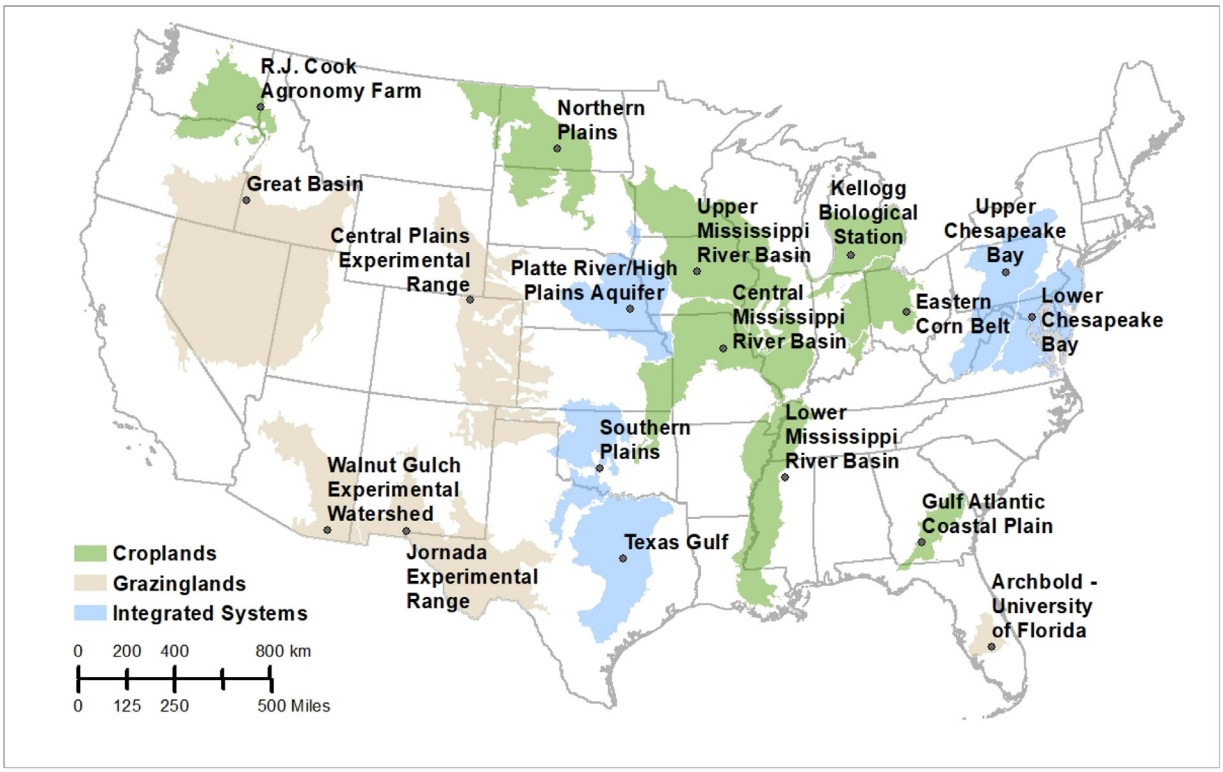

Figure 1. The LTAR Network within the USDA Agricultural Research Service in the contiguous United States. Source: USDA-ARS.

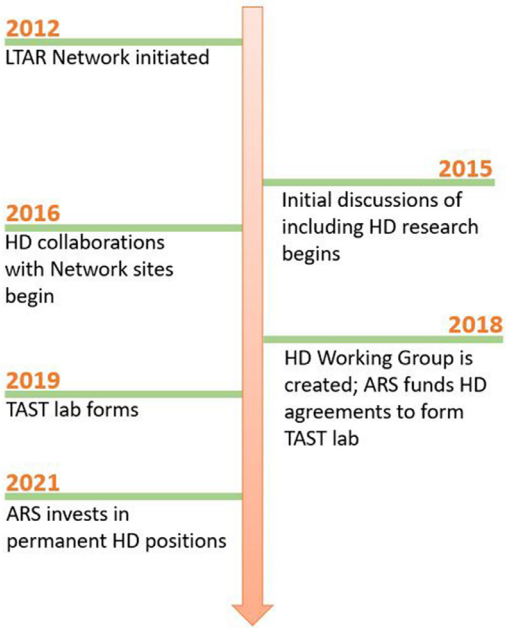

Figure 2. Timeline of LTAR HD research initiatives. ARS indicates Agricultural Research Service; HD, human dimensions; LTAR, Long-Term Agroecosystem Research; TAST, Transformational Agroecosystem Science Team.

LTAR Network was founded to provide "comprehensive, systems-level understanding of the linkages among basic biophysical processes and human activity."[9] This system level understanding was envisioned to span across the food system and its members. However, the LTAR Network's vision originally included a limited scope of potential for human dimensions research, focusing only on economic variables of community vitality and reducing producers' barriers to adoption of innovations.[9] Yet, the lens of economic viability is too limited to capture complex relationships existing between land stewardship and well-being of individuals and communities. The multiple values, especially those related to subjective well-being, that underlie land stewardship cannot be accurately represented through neoclassical economics alone.[10] Consequently, enhancing rural prosperity—the third mission of the LTAR Network—was historically de-valued and given little recognition, resources, and scientific advancement.[5,11] In fact, according to a recent internal poll of LTAR scientists, societal outcomes were perceived as least important for consideration in assessing outcomes of ASP agricultural practices.[5] That being said, some social science was occurring at individual sites within the LTAR Network, including evaluations of economic impacts of crop diversification at the Northern Plains[12] and collaborative adaptive rangeland management at the Central Plains[13] LTAR sites. Acknowledging the need for cohesive network-wide integration of human dimensions and biophysical research, leadership within LTAR started prioritizing strategies to increase human dimensions capacity.

A transformation in thought is underway across the LTAR Network to recognize that human dimensions research is fundamental for understanding the linkages between social and ecological processes (Fig. 2). This reframing extends the research beyond questions about rural prosperity in terms of economic viability and cost benefit analyses to reframe LTAR's third mission as enhancing individual and community well-being.[14] For example, research designed to explore and describe the positive and negative impacts of social changes

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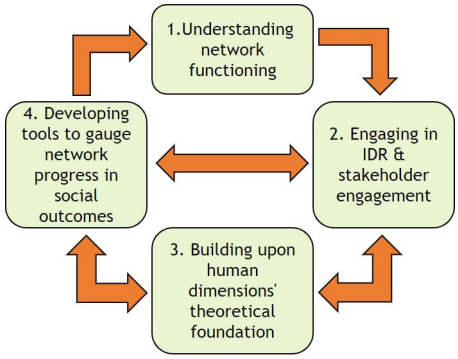

Figure 3. Framework strategy for human dimensions research integration in the LTAR Network or other natural resource research networks. IDR indicates interdisciplinary research.

like suburbanization and rural de-population to individuals, families, and farming and ranching communities provides critical context for BAU and ASP assessments. Such research also sheds light on broader societal issues that may affect innovation and adoption at the farm or ranch scale, as well as collaborative adaptive management at site and regional scales. In 2018, the HDWG was created to bring together social scientists both within the LTAR Network and outside (i.e., University collaborators and external agency partners) to create a cohesive vision of human dimensions research goals and to develop a strategy for integrating these goals into LTAR's research agenda (Fig. 3). In late 2019, the TAST was formed to increase LTAR's HDWG's capacity through collaboration between USDA-ARS and academic scientists. With this surge in human dimensions research, LTAR has more capacity than ever to be a transformative leader in agroecological research in the United States. This leadership can be accomplished by shifting to a model based on co-innovation with stakeholders and one that considers diverse components of the North American food system.

Research framework for agroecological transformation

To realize a transformative vision of agroecosystems, we outline four, concurrent and nonmutually exclusive research steps within a framework that must be undertaken: 1) understanding LTAR Network functioning, 2) engaging in interdisciplinary research and stakeholder engagement, 3) building human dimensions theoretical foundations, and 4) developing tools to gauge progress (Fig. 3). These steps are iterative in that once a baseline understanding of an LTAR Network function is determined (step 1), continued refinement of steps 2 to 4 feed back into step 1 for cohesive network-wide transformation. In the following paragraphs, we explain each of these four steps, which can be adapted to any research network wishing to better incorporate human dimensions research.

Human dimensions (HD) research is underway in the following eight topical areas: agro-innovation systems' collaborations and structure; advancing stakeholder engagement strategies; agro-landscapes and communities in transition; human dimensions of nutrient cycling in agriculture; soil health and well-being; regionalization and agroecosystem indicators of well-being and vulnerability; rural community well-being; and digital agriculture and place connection. Each of these research topical areas relates to one or more steps of the framework. As such, we showcase an example of recent or ongoing HD research for each step. More information about ongoing and future research pursuits is available at https://www.uidaho.edu/cnr/ltar-tast/research.

Step 1: Develop a baseline understanding of LTAR Network function

Understanding how the science of agricultural innovation is accomplished helps to inform ways to transform agricultural systems so that they are more sustainable and equitable.[15] Having baseline data about the institutional structure and function of the LTAR Network (step 1) is crucial to gauging long-term progress (step 4) by retrospectively revisiting the data to assess shifts in the Network through time, and identifying ways to increase the research impact enabled by the LTAR Network's structure (e.g., strategic planning, multi-site research projects) (Fig. 3). Additionally, the baseline data allows for an analysis and list of recommendations on how to allocate LTAR capacity and resources to address gaps and promote LTAR's innovation potential to reach its mission of sustainable intensification (Box 1).

Step 2: Engaging in interdisciplinary research and stakeholder engagement

Interdisciplinary research (IDR) has the power to advance the ASP treatment vision to be truly transformational, and most scientists agree that IDR is essential to studying social-ecological systems like agroecosystems. However, in practicality, institutional and administrative barriers (e.g., career advancement metrics, maintaining compliance with the Federal Advisory Committee Act's guidelines on stakeholder engagement, etc.) and ontological and epistemological differences make achieving IDR collaboration and stakeholder engagement difficult.[16,17] Recognizing the collaboration of LTAR Network scientists and how they are incorporating local stakeholders into their research establishes a baseline of current IDR research engagement (step 1) and informs what further measures should be taken to involve a wide array of scientists and stakeholders (step 2). Additionally, building human dimensions' theoretical foundations with agroecosystem stakeholders (step 3) feeds back into how we integrate IDR research and stakeholder engagement, creating an adaptive loop (Fig. 3).

IDR is not a simple exchange of knowledge; rather, it's a co-construction of knowledge from different disciplines and viewpoints that requires communicative capacity (i.e., listening and speaking across disciplinary boundaries).[18,19] To

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Box 1. Advancing the science of networked research

LTAR is a networked science system that aims to advance a common mission of sustainable intensification through collaborative research. A networked science system is the institutions, infrastructure, partners, and priorities involved in the research process. Applying network science to understand the research processes within LTAR helps to identify strengths, potential gaps, and opportunities that can foster change to help the LTAR Network achieve its mission (Fig. 4). Research in this topical area aims to understand how the LTAR Network sites identify what research or innovations to conduct, the institutional structure of LTAR, and how to best cultivate innovation development potential. Additionally, this research examines how to foster impactful collaboration across the network, identifying gaps in which research partners are being engaged and avenues for successful collaboration with underrepresented partners. In particular, the research aims to make recommendations on how to leverage partner engagement within LTAR to increase its innovations' effectiveness to promote well-being of individuals and rural communities.

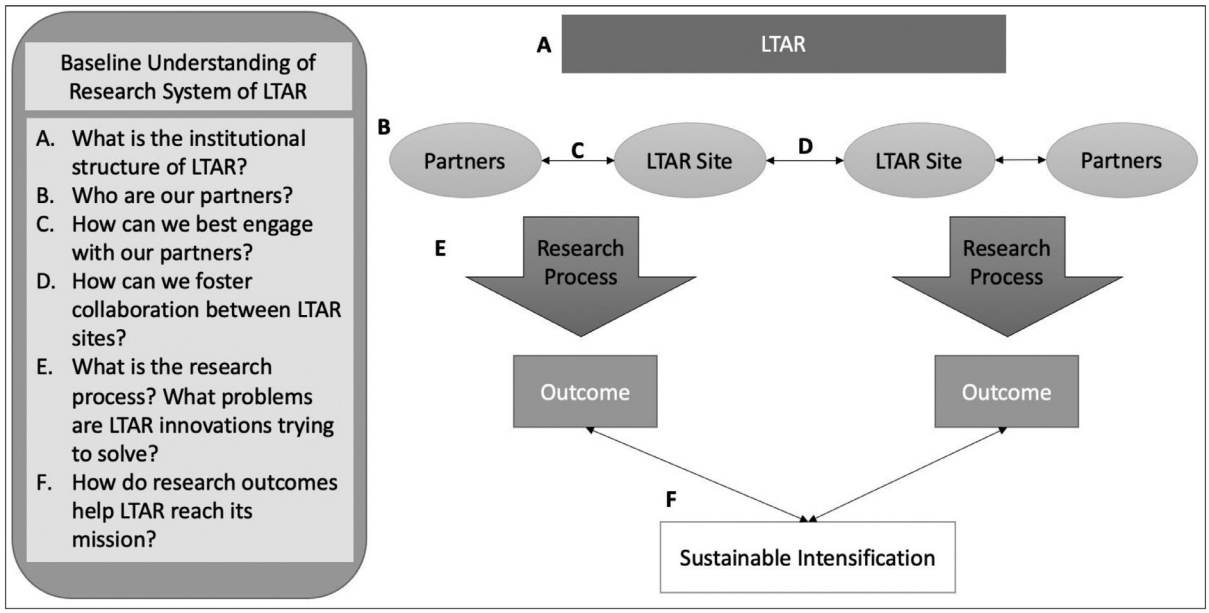

Figure 4. Research process for understanding the LTAR Network function.

achieve communicative capacity, the following five primary principles have been outlined in IDR literature[18]: intellectual confidence, intellectual humility, intellectual generosity, intellectual flexibility, and intellectual integrity. Intellectual confidence is knowing you have important information to contribute to the collaboration and holding yourself accountable for the quality of that contribution. Intellectual humility is realizing that your knowledge is always incomplete and can be revised to include others' views/data. Intellectual generosity is acknowledging the work of others through explicit expression of appreciation of their effort and creativity. Intellectual flexibility is changing your perspective based on others' views/data. Lastly, intellectual integrity is participating fully in the collaborative process to develop trust among collaborators. Even though these seem common-sense, they are easily overlooked and can have detrimental impacts on IDR if neglected. Moving forward, the LTAR Network, and likely many research networks, would benefit from considering these principles when collaborating with scientists and other stakeholders alike.

Box 2. Understanding engagement: learning to leverage research collaboration for innovation

Informal forms of collaboration have typically been an underappreciated form of stakeholder engagement within the LTAR Network. Recent interviews of researchers and cooperating farmers have indicated that such cooperation is increasing the innovation capacity of LTAR. Informal interactions among researchers and producers have helped to identify new research questions and refine study designs to increase the robustness of findings. However, the impact of these collaborations is more wide-ranging because of the potential to increase relevancy and trust that producers associate with USDA-ARS and its research; thus, increasing the likelihood that stakeholders will base their management on the findings of LTAR's research. However, not all sites collaborate with producers to the same extent. Describing the value of these collaborations and providing strategies to increase their effectiveness can help to move the Network in a direction where collaborative research gains more organizational support. Along with this support, is the potential for coordination across the Network to increase the impact of this research approach.

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One goal of the human dimensions research effort is augmenting the capacity for stakeholder engagement within LTAR. These efforts are taking two different approaches: 1) understanding formal and informal mechanisms of stakeholder engagement and 2) engaging stakeholders in visioning exercises. LTAR has both formal and informal means of engaging with stakeholders. An example of formal stakeholder engagement at the Central Plains LTAR site is discussed in-depth in Wilmer et al.[20] (this issue). Informal stakeholder engagement is often a result of day-to-day ad hoc interactions with producers and research conducted with cooperating producers on private lands (Box 2). The HDWG has also been involved in facilitating visioning of future food systems and ASP systems in the presence of social-ecological change. These visioning efforts have been undertaken to help guide research agendas at individual sites integrating the perspectives of stakeholders into their long-term research planning. The visioning exercises aim to bring together diverse food system stakeholder perspectives to develop "out of the box" system-level change ideas. The facilitated exercises aim to examine the tacit assumptions that underlie most agricultural innovations that perpetuate the status quo agricultural system and identify innovation potential that promotes individual and community well-being within the food system.

Step 3: Building upon human dimensions' theoretical foundation

More information is needed to advance our understanding of the complex relationship individuals and communities have with agricultural practices and the environment to advance our progress toward a sustainable agroecosystem.[14,21] As we improve our understanding of these relations, we will use this information to improve stakeholder engagement and interdisciplinary research strategies (step 2) and create better tools used to gauge LTAR Network progress (step 4; Fig. 3). Social-ecological systems research in this domain is aimed at understanding governance, social change processes, impacts of environmental stressors, linkages between environment and well-being, valuation of agroecosystems, stakeholder communication, and environmental management decision-making (Box 3).

Box 3. Integrated framework as a guide for network science on social-ecological processes and impacts to well-being

As a nationwide research network, LTAR comprises multiple disciplines and agroecosystem types, hence the need for a set of concepts grounded in theoretical foundations to serve as a unifying framework. Such a tool is necessary for interdisciplinary communication and to guide descriptions of environmental change, agricultural practices, and impacts to ecosystem health and human well-being across LTAR sites. Human dimensions research at the Great Basin LTAR site provided an opportunity to understand how rural community well-being can be supported and sustained in tandem with the conservation of biodiversity and sustainable intensification of agroecosystems. Findings from the Great Basin effort align with theory on social interactions and ecosystem services, elaborate popular characterizations of well-being, and expand previously established frameworks on human-nature relationships to include concepts representing community.[14] Semistructured interviews with livestock producers, public land managers, recreationists, and conservationists in the Northern Great Basin revealed nuances of communal processes like collaborative management and public lands litigation that support and degrade human well-being and ecosystem health. For the LTAR Network, the resulting integrated framework equips collaborators with concepts and theoretical foundations necessary to identify, describe, and understand social-ecological dynamics and their impacts to agricultural producers, partners, and rural communities across rangelands, croplands, and integrated production systems.[14]

Step 4: Developing tools to gauge network progress in social outcomes

Describing indicators of rural well-being and monitoring them through time (step 4) can help identify their spatial and temporal variation and prompt researchers to evaluate factors associated with any variation (step 3; Fig. 3). Spiegal et al.[22] (this issue) discuss an effort underway within the LTAR Network to determine a set of indicators to measure "common experiment" management outcomes in relation to sustainable intensification goals in five domains (environment, productivity, economic, human condition, and social). Developing indicators within the economic (e.g., financial resilience), human condition (e.g., occupational stressors), and social domains (e.g., community security) has proven more difficult than developing indicators for the environment and productivity domains. Through researcher partnerships and literature reviews, initial example indicators have been formed; however, engagement with stakeholders will be required to effectively select indicators most relevant to producers (connectivity between steps 2 and 4; Fig. 3).[22]

The idea that social, environmental, and economic parameters are necessary to understand how well a system is functioning is not a new one.[23] Regional boundaries are a means of identifying areas of collective patterns of biophysical and socioeconomic factors.[24] Regional frameworks are necessary if observations and model results are to be extrapolated to larger scales for long-term agricultural management decisions.[25] However, well-established regional frameworks have been primarily based on biophysical variables (e.g., the Major Land Resource Areas or the Environmental Protection Agency's EcoRegions).

The LTAR regionalization project is one of several grassroots efforts taking place across the LTAR Network and represents a coordinated research effort to answer fundamental questions, such as how representative is the LTAR Network of agriculture in the contiguous United States? And how can the LTAR Network regionally extrapolate the findings from common experiments? To begin to answer these

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questions, scientists and technicians within the LTAR Network are identifying the most critical agronomic, environmental, economic, and cultural variables to delineate regions. In a 2016 internal survey of LTAR's Remote Sensing and geographic information systems (GIS) Working group, addressing socioeconomic questions was determined to be highly impactful but also very difficult to measure because of a lack of expertise.[26] However, the formation of the HDWG has provided an opportunity for incorporating social dimensions into regionalization efforts (Box 4). Beyond its use as a tool to gauge LTAR Network progress (step 4), GIS and regionalization mapping can also be a practical tool to facilitate interdisciplinary research (step 2) because it provides graphical representation at multiple scales of environmental and social variables that serve as a base for integrated thinking.[16]

Box 4. Indicator development for understanding the human context of agroecosystems

Understanding the human context of agroecosystems is important to understanding the potential for, and impacts of, the adoption of sustainable intensification practices. The LTAR Network's HDWG has provided intellectual leadership for the selection of indicators of human context and well-being. The HDWG has developed a three-phased, iterative approach to indicator selection. Broadly speaking, these phases will shift the way in which human context and well-being are conceptualized, from the economic, to capitals, to culture and self-actualization. Such a synthesis is inherently complex. For this reason, the HDWG is using a combination of dialog and structured scoring processes to integrate the diverse social science expertise of the HDWG into the process. This adaptation of other structured indicator selection processes (e.g., Liberati et al.[27]) can help form the basis of dialogs within the HDWG and among other working groups within LTAR. Ultimately, via this approach, the way in which individuals and society are affected by agroecosystems and their impact on such systems will be better understood, conceptualized, and accounted for, which can inform discussions regarding sustainable intensification.

Conclusions and recommendations

By implementing long-term social-ecological systems research at 18 agroecological sites across the United States, the LTAR Network has an unprecedented opportunity to understand and inform social change processes and rural well-being within working lands. As we have briefly outlined, the transformative impact of the LTAR Network rests in its ability to combine knowledge and innovation co-production within a cohesive, long-term social-ecological systems research effort. This is not a new insight; Robertson et al.[9] posited that to effect solutions the LTAR Network depended on long-term research "because robust solutions to many of the problems facing agriculture require evaluation in the context of climatic, social, ecological, and other factors that change on decadal (or longer) time scales." The value of long-term ecological data has long been accepted; however, long-term social data efforts are still lagging. The research process that the HDWG and TAST are undertaking represents an approach for improving the ability of LTAR to answer its mission of effecting solutions to agroecological problems in a transformative way. However, this process (Fig. 3) is geared toward implementing a human dimensions agenda and should be periodically revisited to adapt efforts to the current state of the LTAR Network.

The institutional support for human dimensions research within LTAR is growing, but without long-term strategies to ensure funding remains in place, social-ecological agroecosystem research will be piecemeal and will struggle to make substantive conclusions into the future. Lessons learned from the LTER network's efforts to integrate social science show that longstanding collaborations, rather than short duration "pop-up" collaborations, are more effective. Incentivizing USDA-ARS employees to engage in the LTAR Network by further rewarding IDR and resulting publications will be critical. This can be facilitated through assigning value to IDR in the proposal review process so that integrative research is not funded in fragments.[8] Furthermore, increasing LTAR's engagement with partner institutions will be needed to further contextualize research questions and maximally leverage research impact. Encouraging LTAR site visits and exchange of data among researchers, university partners, and outside partners (producer groups, NGOs, etc.) would also foster stronger interpersonal connections. Lastly, creating permanent HD positions within the LTAR Network will help shape HD research continuity, guide IDR, and inform stakeholder engagement practices.

Furthermore, stakeholder engagement should be recognized as integral to interdisciplinary research efforts. One exemplary LTAR effort to integrate stakeholders into management decisions is the Collaborative Adaptive Rangeland Management project at the Central Plains LTAR site. The LTAR Network would likely benefit from replicating such collaborative stakeholder groups in other regions.[20] Organizational support and training to build capacity for effective engagement would increase the integration of stakeholder views and values in research; however, it must also be recognized when such engagement needs dedicated facilitators. We propose the LTAR Network adopt several stakeholder engagement best practices. First, a framework should be created that facilitates inclusive, systematic representation of stakeholders across agricultural practices and the larger food system. By necessity, this framework acknowledges tensions between conventional and alternative food systems and facilitates solutions that support a diversity of foodways, food security, resilience, and self-determination of communities. Second, stemming from this framework, LTAR's stakeholder engagement process should balance stakeholders' power with their level of interest and the potential impact innovations have on their well-being.

Ultimately, relying on stakeholders to direct ASP research may help LTAR provide leadership for the transformation of sustainable intensification of agriculture to maximize hu-

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man condition, economic, social, productivity, and environmental outcomes.[22] In turn, stakeholders such as ranchers will have direct impact on research processes with bearing on their livelihoods and well-being. As human and natural systems research is coupled and our agroecosystems are transformed with sustainable intensification goals in mind, society will be the ultimate beneficiary of these changes.

Declaration of Competing Interest

None.

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