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Show-Me Resilience: Assessing and Reconciling Rural Leaders' Perceptions of Climate Resilience in Missouri

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Abstract

Rural areas of the United States play a vital role in coping with, adapting to and mitigating climate change, yet they often lag urban areas in climate planning and action. Rural leaders—e.g., policymakers, state/federal agency professionals, non-profit organization leadership, and scholars – are pivotal for driving the programs and policies that support resilient practices, but our understanding of their perspectives on climate resilience writ large is limited. We conducted semi-structured interviews with 23 rural leaders in Missouri to elucidate their conceptualizations of climate resilience and identify catalysts and constraints for climate adaptation planning and action across rural landscapes. We investigated participants' perceptions of the major vulnerabilities of rural communities and landscapes, threats to rural areas, and potential steps for making rural Missouri more resilient in the face of climate change. We found that most rural leaders conceptualized climate resilience as responding to hazardous events rather than anticipating or planning for hazardous trends. The predominant threats identified were flooding and drought, which aligns with climate projections for the Midwest. Participants proposed a wide variety of specific steps to enhance resilience but had the highest agreement about the utility of expanding existing programs. The most comprehensive suite of solutions was offered by participants who conceptualized resilience as involving social, ecological, and economic systems, underscoring the importance of broad thinking for developing more holistic solutions to climate-associated threats and the potential impact of greater collaboration across domains. We highlight and discuss a Missouri-based levee setback project that was identified by participants as a showcase of collaborative resilience-building.

Keywords Climate change adaptation · Rural resilience · Social-ecological systems · Community capitals · NOAA steps to resilience · Climate vulnerability

Introduction

Climate change is impacting social, economic, and ecological systems at all scales (IPCC 2022). Characterized by unpredictable, spatially heterogeneous, and shifting weather patterns and events, climate change poses global challenges that vary by region (IPCC 2022). In the US, western states face increasing frequency and severity of droughts and wildfires (Weiskopf et al. 2020), coastal states confront sea level rise and increasing storm surges (Garner et al. 2017; Sweet et al. 2017), and the Midwest contends with increased precipitation, more extreme rainfall events, and earlier peak flows (Byun et al. 2019) among other impacts. Given this breadth of impacts, there are likely few 'one size

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fits all' adaptation responses, and decision-makers will need to tailor climate adaptation responses to their region. Thus, better understanding how decision-makers across multiple scales and regions perceive climate-related threats may help inform efforts to minimize risk to local communities, ecosystems, and economies.

Literature Review

Effective climate adaptation requires the coordination of decision-makers and stakeholders with different levels of scientific background, diverse ideological perspectives, varying incentive structures, and contrasting perceptions of climate change (Meerow and Woodruff 2020). Although diverse, inclusive processes can strengthen climate change planning, challenges coordinating among actors, communication failures, and disparities in knowledge and priorities can pose barriers for successful adaptation (Spires et al. 2014; Piggott-McKellar et al. 2019). These challenges manifest across the rural-urban divide in the US, where climate change perceptions vary according to ideology, beliefs, and political affiliation, with urban areas typically leaning liberal and rural areas trending more conservative (Howe et al. 2015; Gimpel et al. 2020). For example, rural midwestern farmers may be more likely to remain skeptical about the cause, certainty, and severity of climate change, whereas residents of urban areas tend to have higher concern about climate change (Howe et al. 2015; Olson-Hazboun and Howe 2018). Urban areas also tend to have more formal climate plans in place (Castán Broto and Bulkeley 2013; Chatrchyan et al. 2017; Mase et al. 2017; Lamb et al. 2019; Aderonmu et al. 2021), whereas rural areas often lack defined climate plans and have fewer financial resources, making them more dependent on external support for disaster recovery (Javadinejad et al. 2019). Fragmentation of responsibilities and jurisdictional control also complicates adaptation efforts in rural areas (Bierbaum et al. 2013). Together, these factors suggest that rural areas face distinct challenges in developing more resilient landscapes and practices in the face of climate change.

The concept of resilience is widely used in academic and policy spaces, and it has become central to planning practice, especially for climate adaptation, as localities are increasingly framing efforts to grapple with climate change as resilience initiatives (Meerow et al. 2016; Woodruff et al. 2022). However, resilience remains a complex and multidimensional concept that is defined differently within and across disciplines (Sharifi 2016; Payne et al. 2021), and some argue that this divergence can inhibit adaptation efforts (Fisichelli et al. 2016). Early efforts to conceptualize resilience in relation to the environment focused on understanding resilience in terms of multiple basins of attractions in ecosystems (Holling 1973). Subsequent work expanded the resilience lens to include elements such as adaptive cycles in human and natural systems (Berkes and Folke 1998; Gunderson and Holling 2002), institutional diversity (Ostrom 2005), and other foci (Folke 2016). Acknowledging these diverse, complementary, and—at times—contested views of resilience, here we utilize the term according to the 2022 IPCC Report, which offers an encompassing definition that can be applied across a wide range of scales and contexts. The IPCC defines resilience as "the capacity of interconnected social, economic, and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure" (IPCC 2022, pp. 2920–2921).

Many efforts have been made to operationalize processes designed to assess, maintain or enhance resilience (Fuller and Lain 2015; FAO 2018). These frameworks can broadly be grouped into descriptive, causal, and analytical models of resilience (Serfilippi and Ramnath 2018). When applied to planning endeavors, resilience frameworks often follow a similar cycle of planning stages: framing the problem, identifying risks, articulating and evaluating options, developing a plan, acting, and monitoring and evaluating outcomes (Palutikof et al. 2019). For example, the Steps to Resilience Framework is an iterative, 5-step process developed by the National Oceanic and Atmospheric Administration (NOAA 2022). The NOAA Steps to Resilience are (1) understand exposure, (2) assess vulnerability and risk, (3) investigate options, (4) prioritize and plan, and (5) take action (NOAA 2022). It is a widely used framework within the United States that can be applied across a range of focal areas and scales, including individual cities, regions, and states. For example, the framework was used to guide the development of the city of Blacksburg, Virginia's Climate Vulnerability assessment and the state of North Carolina's Climate Risk Assessment and Resilience Plan (NOAA 2022).

Research on rural planning suggests that many rural areas lack the infrastructure to fully engage in resilience planning and that plans in rural areas often face shortcomings compared to their urban counterparts (Cox and Hamlen 2014; Horney et al. 2017). However, other scholars note that "rurality can confer certain advantages when it comes to resilience" such as stronger social bonds, available natural resources, and a culture of self-reliance (Lamb 2020, p. 289). Given these complexities, a capitals perspective offers one potentially useful way to examine rural resilience (Mayunga 2007). The Community Capitals Framework, developed by Emery et al. (2006), posits that communities possess and can mobilize varying levels and ratios of seven types of capital. These seven capitals are natural, human, cultural, social, political, built, and financial. Other scholars include an additional capital, institutional capital, which

relates to the systems of rules and governance, as well as the coordination and performance of both public and private institutions (Farmer et al. 2012). Although scholars often use the Community Capitals Framework to explore classes of assets at a community scale, the framework can apply to broader scales and may also be used to better understand and categorize constraining factors within systems (Sketch et al. 2020).

Despite having only 19% of the population, rural areas comprise approximately 97% of land in the United States (US Census Bureau 2016). Therefore, many activities related to the maintenance of ecosystem services, management of natural resources for goods and services, and implementation of large-scale adaptation and mitigation efforts falls under rural purview. Rural leaders—from officials in state and federal agencies to advocacy groups and lawmakers—are often responsible for championing, promulgating, and overseeing the programs and policies related to rural land-use (Daniell et al. 2013; Lyle 2015). Although scholars have explored the ways decision-makers and other practitioners understand and deploy the concept of resilience in their work (Aldunce et al. 2015; Meerow and Stults 2016; Oulahen et al. 2019) there remains uncertainty in how rural practitioners operating at a landscape-scale understand and apply the concept and the way those conceptualizations influence their approaches to grappling with climate change. Pinpointing how rural leaders perceive climate threats and conceptualize climate resilience remains a challenging, but critical, step for climate adaptation, as these groups' perceptions also influence decision-making at larger scales and because, globally, more than half the world's population resides in small, rural municipalities (Daniell et al. 2013; Lyle 2015; Bausch and Koziol 2020).

Research Aims

Research has primarily focused on urban, rather than rural, conceptualizations of resilience in the face of climate change. Understanding the interplay among rural leaders' conceptualizations of resilience, perceptions of threats and vulnerabilities, and proposed solutions may offer insights for how these elements interact in rural milieux around the globe. This can inform the development of rural and regional planning frameworks.

Focusing on rural Missouri as a case study, we explore how leaders engaged in rural, landscape-scale decision making—i.e., in agriculture, conservation, and natural resources - conceptualize resilience in the context of climate change. Missouri is experiencing changing temperature and precipitation patterns. The most marked changes include warmer minimum temperatures, extended growing seasons, more frequent droughts, increased annual precipitation, and more extreme rainfall events (Kunkel et al. 2013; Pryor et al. 2014). Missouri has seen an increase in major flood events over the last two decades, causing extensive crop loss and damage to infrastructure, and climate projections suggest that floods are likely to increase in frequency and intensity across the Midwest (Kunkel et al. 2013; Hershon 2020; Neri et al. 2020).

Given this context, we explore the following research questions:

RQ1: How do rural leaders conceptualize resilience in the context of climate change?

RQ2: What are the major threats to rural Missouri's communities and landscapes identified by rural leaders?

RQ3: What climate change vulnerabilities of rural Missouri's communities and landscapes are identified by leaders?

RQ4: What specific steps do rural leaders identify that could make rural Missouri more resilient in the face of climate change?

Methods

We use a qualitative data collection and analysis approach as an exploratory method to identify key themes and areas for further research. Semi-structured interviews allow interviewers to probe and follow emergent information while still adhering to an overarching focus (Knox and Burkard 2014). They can help researchers learn about topics that are important to the interviewee but unknown to the researcher (Young et al. 2018). Here, we describe our process of recruiting interviewees, conducting interviews, and analyzing results.

Sample Population

We focused on leaders operating at the landscape-level in rural Missouri, especially those in fields such as agriculture, natural resource management and conservation. We use the term 'leader' to describe individuals with extensive background knowledge, access to privileged information, and/or those that are responsible for informing, prioritizing, developing, and/or implementing programs, policies, or decision-making (Otto-Banaszak et al. 2011). To identify potential subjects, we first conducted preliminary interviews with four

key informants, from whom we also sought insights about pertinent topics and resources associated with our research questions. We selected these key informants in consultation with a non-partisan science policy nonprofit organization (MOST Policy Initiative) operating at the state level in Missouri. These informants work extensively within the rural land-use sphere in the state and have broad connections with leaders across disciplines and ideologies in Missouri.

Drawing on those preliminary interviews and targeted internet searches to identify leaders at relevant agencies, institutes, and organizations, we identified an initial pool of 40 potential participants. We sought leaders with a range of vantages on rural Missouri, including legislators, academics, state and federal agency professionals, and representatives from nongovernmental organizations. We sent recruitment emails to all potential participants inviting them to participate. If they did not respond, we sent a follow-up email approximately one week later. We also sought additional interview subjects during interviews through snowball sampling (Bernard 2006). We asked each interviewee to identify additional relevant candidates. If that candidate matched an underrepresented perspective in our sample, we requested an interview with the subject (Patton 2002). Three participants were added via snowball sampling. We stopped seeking additional interview subjects when we reached theoretical saturation, a point in our iterative process of data collection and analysis wherein no new insights and themes emerged from additional data collection and analysis (Strauss and Corbin 1990).

In total, we conducted 23 interviews from March to May 2022. All interview candidates belonged to one of four sectors: non-profit organization ($n = 10$), state/federal agency ($n = 4$), the Missouri General Assembly ($n = 6$), and university ($n = 3$). All participants from agencies and nonprofits held leadership roles (Table 1). Four of the six legislators were appointed to rural districts, and two were appointed to urban districts but served on committees related to agriculture, conservation, natural resources, and/or rural economic development.

All participants held a bachelors-level degree or higher. Seven participants held terminal degrees (i.e., PhD or law degree), and five held masters' levels degrees. Eighteen participants had academic backgrounds in STEM or agriculture, thirteen had personal backgrounds in farming, and participants had an average of 17 years of experience in their field. Seven participants were women and 16 were men.

Interview Protocol

We conducted interviews either in-person ($n = 10$) or via Zoom video-call ($n = 13$). The interviews lasted an average of 43 min (range: 20–66 min). Our primary interview themes were guided by the first three steps from NOAA's Steps to Resilience (NOAA 2022): (1) explore exposure, (2) assess vulnerability and risk, and (3) investigate options (Fig. 1). Thus, during the semi-structured interviews, we asked participants about their understanding of resilience and their perceptions of vulnerabilities, major threats, and potential solutions within the context of climate resilience in rural Missouri (see Supplementary Materials for interview

Table 1 List of interviewed positions and agencies, institutions, or organizations

Positions (# individuals)	Total	Agency, institution, or organization	Total
Executive Director (3), Deputy Director (2), Legislative Liaison (1), Policy Coordinator (2), State Coordinator (1), State Conservationist (1), State Director (1), Director of Regulatory Affairs (1), Executive Vice President (1), Director of Research (1), Faculty (2), Extension (1), State Representative (6)	23	Missouri Department of Agriculture, Missouri Department of Conservation, Missouri Department of Natural Resources, USDA Natural Resources, Environment Missouri, Missouri Coalition for the Environment, Missouri Farm Bureau, Missouri Pork Association, Missouri Soybean Association, The Nature Conservancy, Pheasants/Quail Forever, Missouri Farmers Care, Missouri Energy Initiative, Renew Missouri, University of Missouri, Missouri State Capitol	16

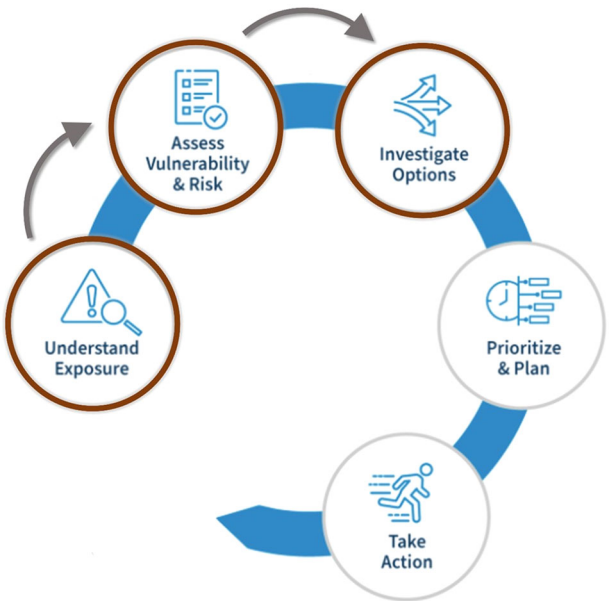

Fig. 1 Conceptual diagram of the steps to resilience. This project focused on steps 1–3 (outlined with dark circles). Figure adapted with permission from NOAA's Climate Resilience Toolkit (NOAA 2022)

protocol). For all climate-related questions, we did not directly attribute climate change to anthropogenic causes (Coleman et al. 2022).

We recorded each interview and transcribed the audio using Otter AI software. We spot checked the transcriptions for accuracy and used these as the basis of all data analysis. Two authors coded each interview using a consensus coding approach to arrive at agreement about each code (Hill et al. 1997). In consensus coding, because authors jointly code the entire corpus of data, there is no intercoder reliability coefficient. In instances of impasse or confusion, we consulted the other authors to achieve resolution. We used QDA Miner Lite for coding interview transcriptions, and we produced all figures using RStudio v1.4.1106 (Rstudio Team, 2020). This project and all associated materials were approved by the University of Missouri Institutional Review Board in March 2022 (Project #2090263). All participants provided informed consent.

Coding Approach

We describe our coding and analytic approaches separately for each research question. The complete codebook is included in the Supplementary Materials. For RQ1, we deductively coded participants' responses to the question "What does resilience mean to you (in the context of climate change for rural Missourians and rural landscapes?)" and other relevant interview segments identified via keyword searches. We coded responses according to the components of the 2012 and 2022 IPCC definition of resilience (IPCC 2012, 2022). A deductive coding approach allowed us to not only identify the aspects of resilience enumerated by workshop participants but also to pinpoint aspects of the IPCC definition of resilience that were underrepresented in–or absent from–participant responses.

For RQ2, we first used an open inductive coding approach (i.e., breaking the textual data into its discrete, salient components) for organizing participants responses to the threats to rural Missouri, as this approach is useful for identifying key concepts from a broad range of responses (Williams and Moser 2019). We then used axial coding (i.e., identifying, organizing, and linking connections between groups) to further clarify, categorize, and refine participants' responses (Williams and Moser 2019).

For RQ3, participants' responses to questions relating to vulnerabilities were deductively coded according to the Community Capitals Framework. Thus, vulnerabilities were coded as a shortage of the capital with which they were most closely associated. We also coded participants' responses for emergent themes related to vulnerability. Through an iterative process of coding and consulting literature, we included 'institutional capital' in addition to the seven capitals identified by Emery et al. (2006).

For RQ4, we coded participants' perspectives on possible steps using open and axial coding. We proceeded through iterative rounds of inductive and deductive coding to address the breadth of steps identified and to categorize them within the Community Capitals Framework. We compared the proportion of responses in each community capital between vulnerabilities and potential steps to elucidate whether participants thought of possible steps within the same domains as the vulnerabilities.

Results

RQ1: How Do Rural Leaders Conceptualize Resilience?

All participants identified at least two of the 12 aspects of the IPCC definition(s) of resilience but varied considerably in the complexity of their responses. The average number of aspects identified by each participant was 5.47 ($SD = 1.5$, range: 2–8). Participants described resilience in the context of economic, ecological, and social systems nearly equally. The most-frequently identified aspects of resilience were 'hazardous event' ($n = 16$) and 'capacity to cope' ($n = 16$), and the least identified aspect was 'interconnected' ($n = 2$). Overall, most participants conceptualized resilience as coping with or responding to a hazardous event and fewer conceptualized it as anticipating or reorganizing for hazardous trends (Fig. 2).

Ten participants thought of resilience as the ability to 'bounce back' after perturbations to the system, or to maintain identity or function. For example:

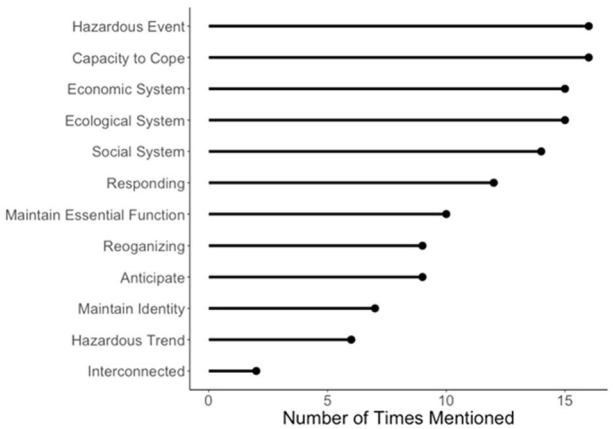

Fig. 2 Conceptualizations of the meaning of resilience. Conceptualization of the meaning of resilience in the context of rural Missouri by rural leaders. Responses were coded according to the IPCC definition of resilience. Each term on the y-axis represents one of the key components of the definition, and the plot is ranked in descending order of the number of times each key component was addressed during the interviews

"Immediately what comes to mind is the ability to weather a challenge or to bounce back from said challenge."

"Resilience to me means being able to adapt to sustain functionality."

"Yeah, resilience is about identity. It's about maintaining identity in the face of changes in the face of disturbance."

Thirteen participants thought of resilience as being able to remain economically viable through ups and downs:

"…when I think of resilience, I think, can we help a producer or farmer, ranch owner, forest landowner, be able to long term handle the ups and downs and the climate instability? Are there ways that we can build a systems approach to help them ride out those ups and downs?"

"To me, it's about making sure that you can continue to operate year in and year out."

One participant conceptualized resilience primarily as a human attribute relating to positivity and determination:

"I think of resilience, in many ways, I think of people being resilient and not giving up and not being discouraged. I think of farmers as resilient when it comes to being optimistic and planning the crops, raising their cattle year after year. I think that resilience is something that has helped our country be strong…"

These quotes suggest some heterogeneity in conceptualizations of resilience. However, most interviewees seemed to focus on stability in the face of recurring challenges.

RQ2: What are the Major Threats to Rural Missouri's Communities and Landscapes Identified by Rural Leaders?

The predominant threats identified by participants related to changing precipitation patterns. Participants identified both changing trends (increasing precipitation and increasing temperatures) as well as more frequent extreme events (heavy rainfall, flooding, and drought; Fig. 3; Table 2). Additional major threats identified by participants included industrial agriculture's reliance on external inputs, demographic changes related to rural exodus, and both regulation and deregulation of agriculture (Fig. 3; Table 2).

For example, two participants summarized the threats related to precipitation trends and increased extreme events as:

"You know, the old timers would say that the rains would come more gentle than they do now. You wouldn't get like five, six-inch rains as a common occurrence."

"On the flooding piece, that's a more immediate threat and I feel like that's ramping up. And I think everybody's recognizing the more intense more frequent weather patterns we're having."

Two additional participants spoke to other major threats:

"You know what is the average age of the farmer now? It's like 57? That's a problem."

"A lot of farmers have a system that's very dependent on using a lot of fertilizer. Well, this year, fertilizer product prices almost doubled."

Overall, participants' perspectives on the threats facing rural Missouri aligned with projections of climate change for the Midwest. They cited changing precipitation patterns, flooding, and drought as their primary concerns. However, they were also keen to point out that rural Missouri simultaneously faces other major internal (e.g., rural exodus) and external (e.g., market forces of commodity crops) pressures that threaten rural vitality. Multiple participants highlighted a need for more creative solutions and problem solving:

"I think, again, we need to start coming up with more creative solutions, and not banking on that business as usual."

"You've got to be creative to engage in problem solving but being creative is extremely difficult and extremely difficult when you're scared to death of losing what you love."

Lastly, some threats mentioned by participants were directly at odds. For example, several participants mentioned deregulation (i.e., loosening regulations on agriculture) as a threat for rural Missouri, especially in the context of confined animal feeding operations. Conversely, other participants thought that regulations (i.e., tightening

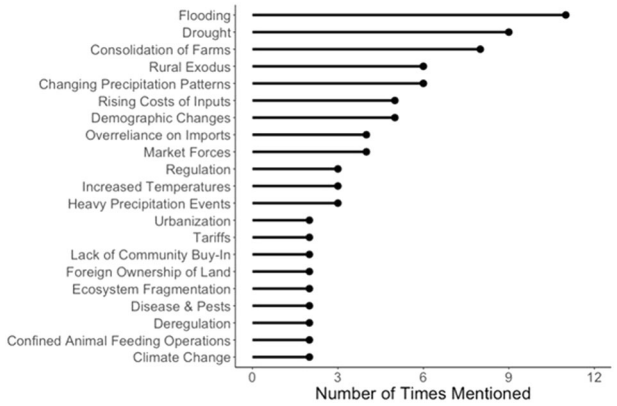

Fig. 3 Leader-identified threats facing rural Missouri. Each term on the y-axis represents threats to rural Missouri, and the plot is ranked in descending order of the number of times each threat was addressed during the interviews after filtering for threats mentioned > 1. For the full list of the threats identified, see Table 2 and additional detail in supplementary materials

regulations) were a threat because they constrict Missourians' ability to earn an income.

RQ3: What Vulnerabilities of Rural Missouri's Communities and Landscapes Are Identified by Leaders?

Participants identified vulnerabilities within seven of the eight community capitals. Those associated with human capital ($n = 18$), natural capital ($n = 17$), and built capital ($n = 15$) were mentioned most often. Only one participant identified vulnerabilities associated with institutional capital, and none identified vulnerabilities in political capital.

A recurring vulnerability highlighted by participants was a lack of systems thinking when facing problems and trying to develop solutions. Participants also identified lack of education, inability to access resources, and incapability to see the bigger picture as the vulnerable components of human capital in rural Missouri, as showcased in the following quotes:

> "I think it's a challenge for our rural communities to see the bigger connectedness of our system, whether we're talking about the food system or overall biosphere."

> "The lack of education and lack of educated people makes things very vulnerable. I think it just leads to people not knowing what to do or how to do it…If you don't have a good education, you're toast."

> "The human capital brain-drain from rural communities [makes rural Missouri vulnerable]."

Table 2 Threats to rural Missouri identified by interview participants

Threat	Detail	*n*
Climate and natural disaster	Flooding	11
	Drought	9
	Changing precipitation patterns	6
	Heavy precipitation events	3
	Increased temperatures (air and water)	3
	Climate change	2
	Diseases and pests	2
	Earthquakes	1
	Extreme weather	1
	Extreme wind	1
	Heatwave	1
	Less predictable weather patterns	1
Industrial agriculture and market forces	Consolidation of farms	8
	Rising input costs	5
	Market forces	4
	Overreliance on imports	4
	Concentrated Animal Feeding Operations (CAFOs)	2
	Foreign ownership	2
	Financial barriers to workforce entry	1
	Monoculture	1
	Novel product classes	1
	Reliance on non-renewable inputs	1
Population factors	Rural exodus	6
	Demographic changes	5
	Urbanization	2
	Novel product classes	1
Political and Social factors	Regulation	3
	Deregulation	2
	"Not in my back yard" (NIMBYism)/ Lack of community buy-in	2
	Tariffs	2
	Geopolitics	1
	Domestic politics	1
	Tax credits	1
	Disconnection from nature	1
Degraded ecosystem	Fragmentation	2
	Invasive species	1
	Contaminated water	1
	Degradation of natural resources	1
	Erosion	1

The vulnerable aspects of natural capital in rural Missouri that participants identified were often related to proximity to river systems, soil health and the heterogeneity of fertile soils, and fragmented habitats, as illustrated in the following quotes:

"I think the smaller the community, the more vulnerable it is, the more you know, the more niche-specialized it is, the more vulnerable it is. And I think that, to me, Ozark streams and things like that, those truly unique ecosystems that only exist in a few places, just by the nature of how specialized they are and how small they are, they're inherently more vulnerable."

"River systems [are vulnerable]. …hardscaping and controlling the river has to change in my opinion, especially with these more intense and more frequent storms. We need to be able to revert river systems back to more of their systematic functions, like maybe let a floodplain be a floodplain instead of you know, channelizing and not allowing the river to expand and shrink based on flows."

"Marginal soils [make parts of Missouri vulnerable]. Like parts of southwest Missouri or the Missouri Ozarks, you know, the soils are very thin, and what little soil was there has often been eroded away."

Despite being asked about vulnerabilities specifically within the context of climate change, participants often identified more general vulnerabilities facing rural Missouri. For example, within built capital, participants identified deteriorating infrastructure—especially bridges, roads, and wastewater treatment facilities – and a lack of broadband access in rural parts of the state as examples of vulnerable or limited capitals. Other important vulnerabilities included the idea of 'rural exodus' and associated cascading effects (e.g., aging rural population, fewer people returning to farming careers, dead and dying small towns, inability for families to earn a viable income in rural areas), the lack of social cohesion (such as distrust in the government and failure of leadership), as well as lacking cultural capital (including ingrained traditions that are reluctant to change and a weak sense of identity across the state).

Lastly, multiple participants mentioned the lack of cohesion and vision across institutions and that there was an absence of big-picture dialogue, planning, and action in the state. Although some agencies had climate agendas in place or in development, respondents felt that contention over the veracity and gravity of climate change within the agency made the policies little more than perfunctory.

RQ4: What Specific Steps Do Rural Leaders Identify That Could Make Rural Missouri More Resilient?

Participants identified a wide variety of specific steps to help make Missouri more resilient. Overall, there was low agreement on specific steps: In only one instance, five participants agreed on a strategy for enhancing resilience. Eight other steps were cited by two or three respondents each, while the remaining 28 distinct steps were mentioned only once (Table 3). Steps that were mentioned more than once are shown in Fig. 4. Actions were cited across all eight community capitals (Table 3). The community capitals with the highest amount of cited specific steps were institutional ($n = 8$), built ($n = 6$), and financial ($n = 6$), and the fewest belonged to cultural ($n = 3$) and political ($n = 2$).

Other important steps (identified by at least two participants) included expanding broadband access, institutionalizing the monitoring of waterways and water quality, improving the profitability of agriculture with value-added products and agritourism, and developing a shared language and vision for the state. Participants' responses illustrate that proposed solutions do not necessarily align directly with the community capitals most-often cited as vulnerable (Fig. 5).

These quotes illustrate the range of specific steps identified by participants:

"We need more integrated landscape practices. So, putting in pollinator habitat, putting in biologically diverse conservation buffers, having tree planting where appropriate, appropriate use of grazing strategies, fitting all those things together, kind of from a landscape perspective is something we don't tend to look at too much. But it's something I've been encouraging people to think about…"

"I think the programs we just talked about are concrete steps, right? I think many of those are already in place. Now, they may not be perfectly implemented, there may be a lot of room in the margin for improvement."

"I think we have to continue to figure out ways to get urban and suburban people to experience, respect, and appreciate rural Missouri and vice versa. Because we're all we're all in this together, you know. We have to stop putting ourselves in our little camps and silos."

"Another thing that we're really starting to break out into [to expand the reach of our programs] is female landowners. We're doing a lot of stuff with getting women outdoors and further developing their skill set outdoors."

Because numerous participants mentioned vulnerabilities associated with siloed thought and action as well as the need

Table 3 Expert-identified specific steps along with the community capital to which they correspond

Primary community capital addressed	Specific step
Built	Enable rural broadband
	Advance energy storage tech
	Advance precision agriculture
	Establish a renewable, diverse, and resilient grid
	Repair infrastructure
	Stop development in floodplains
Natural	Combat invasive plant species
	Diversify crops
	Advance landscape-scale conservation efforts
	Promote native plants
	Support on-farm biodiversity
	Establish/expand riparian corridors
Social	Build shared language and priorities
	Generate urban buy-in for rural priorities
	Conduct more research on rural needs
	Promote social diffusion of innovation
Institutional	Establish consistent regulation across jurisdictions
	Generate revenue through taxation
	Institutionalize monitoring efforts
	Enshrine the right to repair
	Adjust zoning regulations
Financial	Promote agritourism
	Establish hemp/medical marijuana market
	Streamline approval of new technologies
	Support value-added agriculture
	Expand tax credits for farmers
Human	Dismantle silos; encourage systems thinking
	Support education
Cultural	Depoliticize discourse
	Prioritize long-term planning
Political	Advance specific legislation
Crosscutting ideas	Expand existing programs
	Hold strategic listening sessions
	Host landowner workshops

for systems thinking as a specific step, we sought to understand how a *lack* of broad systems thinking might be associated with the breadth of specific steps mentioned by the participants. That is, do participants that identify resilience as

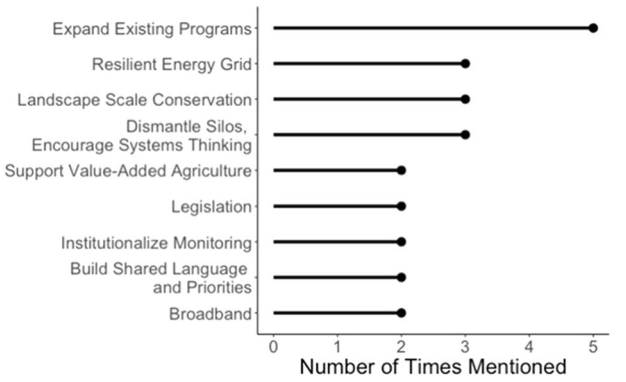

Fig. 4 Leaders-identified specific steps. Leader-identified steps to make rural communities and landscapes in Missouri more resilient. Each term on the y-axis represents a step, and the plot is ranked in descending order of the number of times each was addressed during the interviews after filtering for steps that were mentioned > 1. For the full list of the proposed steps identified, see Table 3

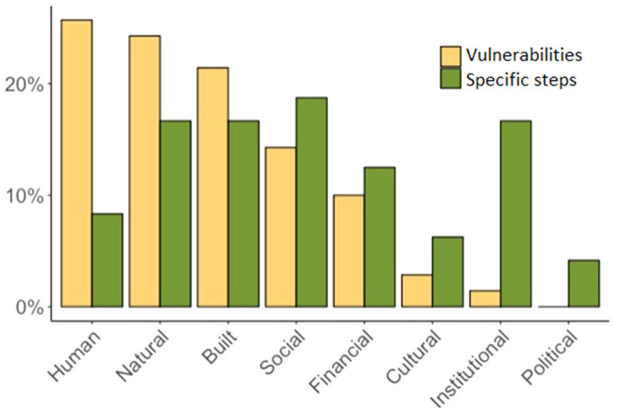

Fig. 5 Vulnerabilities and specific steps. Proportions of participants' responses associated with each community capital for both vulnerabilities (yellow bars) of rural Missouri and specific steps (green bars) towards resilience

narrowly pertaining to a particular system – social, ecological, or economic – propose specific steps across distinct community capitals? We explored this emergent trend using Sankey diagrams depicting the connections between systems identified in participants' conceptualizations of resilience and the community capitals associated with proposed steps to make rural Missouri more resilient. We found that only the participants who described resilience as involving social, ecological, and economic systems identified specific steps in all of the community capitals (Fig. 6). Participants that associated resilience with only one system identified specific steps in fewer of the community capitals. For example, those participants thinking of resilience primarily in economic systems did not identify steps to enhance natural or human capitals; and those thinking of resilience primarily within social or ecological systems did not identify steps associated with political capital.

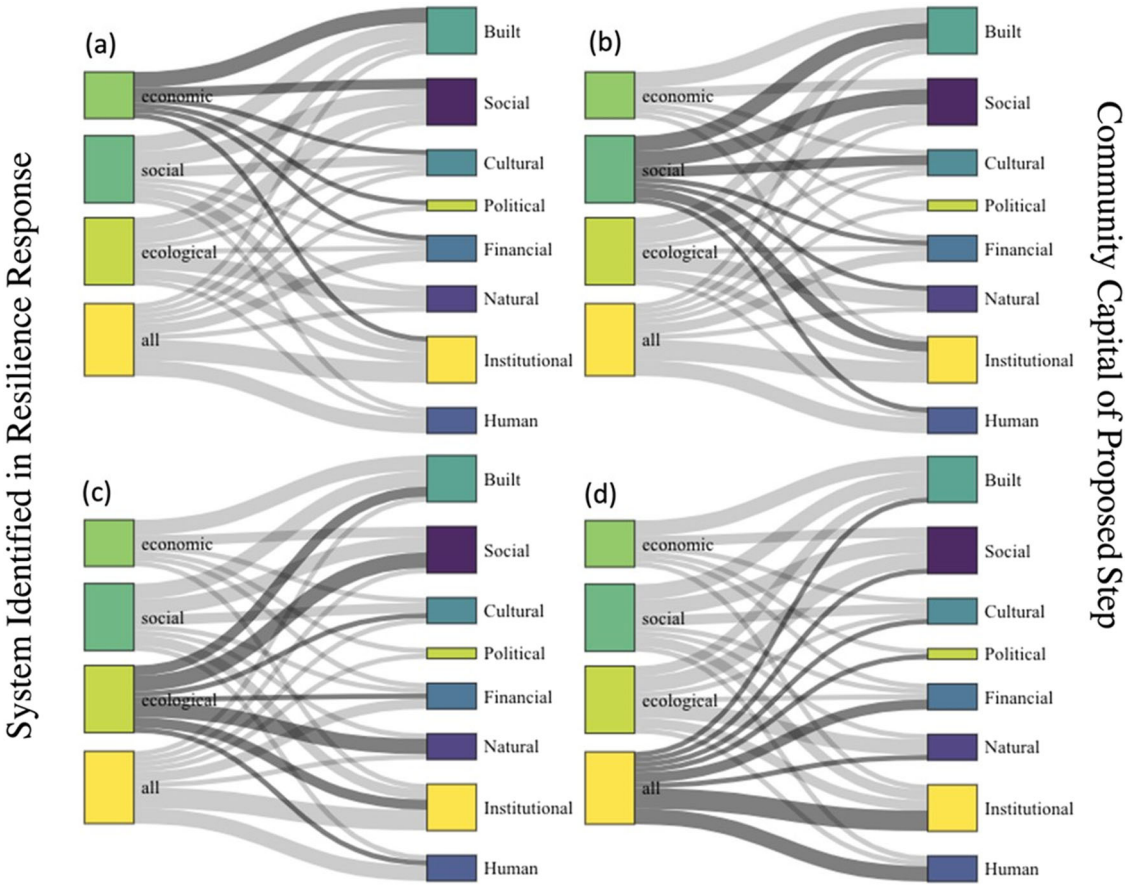

Fig. 6 Sankey diagrams of systems thinking and specific steps. Dark lines depict connections among the systems described in participants' resilience definitions and the Community Capitals targeted in those respondents' proposed solutions for those who primarily identified (**a**) economic, (**b**) social, (**c**) ecological, or (**d**) all systems. Node size represents the total number of connections between systems and capital associated with specific steps

The Atchison County Levee Setback

Multiple participants cited a 2020 levee setback project in Atchison County, Missouri as an example of a successful, well-supported project that enhanced rural resilience. Levee setbacks relocate existing levees to provide rivers with more floodplain for water storage during floods, with benefits that include reduced flood levels and water flows (Dahl et al. 2017), flood risk and damage reduction (Dierauer et al. 2012), and more floodplain habitat for native flora and fauna (Smith et al. 2017). After levee damages incurred from the 2019 Missouri River flood, the Atchison County Levee District led the setback project with support from The Nature Conservancy, the US Army Corps of Engineers, community groups, and several state agencies. Participants hailed this project as a success and remarked that it showcased several attributes of effective resilience-building efforts. First, the effort required and benefitted from collaboration by disparate non-profit organizations, state and federal agencies, and community groups, whose focal areas encompass social, ecological, and economic domains. Second, expanded floodplain habitat along the Missouri River provides additional refuge for waterfowl, amphibians, shallow water fish species, aquatic and riparian flora, and other biodiversity. Third, by reorganizing systems in anticipation of future flood projections, risks to communities and economies are potentially lessened.

Discussion

Through semi-structured interviews with 23 rural leaders at the nexus of rural land-use, agriculture, natural resources, and conservation (Table 1), we sought to elucidate leaders' conceptualizations of climate resilience in rural Missouri. Overall, we found that:

- Participants had diverse conceptualizations of resilience – ranging from primarily attributes of optimism and determination to a focus on disaster recovery and maintenance of functionality. In general, more participants conceptualized resilience as an act of responding to hazardous events rather than anticipating hazardous trends (Fig. 2).

- Participants' perspectives on the threats facing rural Missouri largely aligned with projections of climate change for the Midwest, with floods and droughts cited as the most prominent threats (Fig. 3; Table 2). However, numerous non-climate stressors, such as farm consolidation and demographic changes, also factor into participants' understanding of the threats facing rural Missouri.
- Participants offered a wide range of potential steps to bolster rural resilience, but we found little agreement on specific steps. The possible steps identified most frequently were associated with expanding or adapting existing programs, building a more resilient energy grid, promoting landscape-scale conservation, and encouraging systems thinking (Fig. 4; Table 3).
- Participants identified human, natural, and built capitals as rural Missouri's most vulnerable assets. Most specific steps identified by participants primarily addressed institutional, financial, and built capitals (Fig. 5).
- Participants who described resilience as taking place across interconnected social, ecological, and economic systems identified specific steps that addressed a broader range of capitals compared to participants that primarily described resilience within a single system (Fig. 6).

The leaders in our sample primarily conceptualized resilience as 'bouncing back,' an understanding of resilience which is consistent with the literature (e.g., Nelson 2011; Kais and Islam 2016), where popular perceptions of the objective of resilience is to return to a former state after a disturbance. However, aspects of this conceptualization may be problematic and associated with denial of fundamental problems and avoidance of necessary systemic changes (Handmer 1996; Kais and Islam 2016). Conceptualizations of resilience that are more open, flexible, and adaptive, or that consider 'bouncing forward' to a reorganized future state, tend to be associated with addressing the fundamental cause of the problem and transformational political and cultural shifts (Handmer and Dovers 1996; Shi and Moser 2021).

Similarly, the narrower solution sets offered by participants who conceptualize resilience within only a subset of social, ecological, and economic systems suggests opportunities for broadening the palette of resilience-enhancing measures available to rural leaders through collaboration and developing systems thinking skills. Systems thinking is one vital capacity for leaders attempting to address widespread systemic problems (Hynes et al. 2020). For example, exploring broader solution sets may help rural leaders capitalize on potential co-benefits or opportunities to multisolve challenges (Mason 2021; Sharifi et al. 2021). Systems thinking may also help avert maladaptation, or actions that may be helpful in the short term but ultimately inhibit the ability to cope with climate change long-term (Magnan et al. 2016). Creating opportunities for collaboration across disciplinary silos may also help rural leaders tap additional solutions to resilience challenges (Barzola Iza et al. 2020).

Participants identified insufficient human capital as the primary vulnerability in rural Missouri. Focusing development efforts on building local capacity and leadership may be a promising next step (Barkley et al. 2004). This could include workforce development initiatives leveraging labor market intermediaries, such as cooperative extension, to strengthen community capacity (Hatch et al. 2018). Additional investment into these programs and coordination among their personnel and leadership may support human capital development through avenues such as landowner workshops, farm tours, or strategic listening sessions (Swanson 2008; Tamsan and Yusriadi 2022).

Participants had the highest level of agreement about the value of expanding existing programs as a specific step. For example, several participants noted Missouri's unique conservation and soil, water, and park taxes, which provide funding for a range of programs and services that might contribute to more resilient communities and landscapes (Benson et al. 2008; Pauley et al. 2022). Several state and federal level programs and policies – e.g., landowner assistance programs through the United States Department of Agriculture, the Natural Resources Conservation Service, the Department of Conservation, or the Department of Natural Resources – were also identified by participants as being useful for implementing more resilient practices across the landscape. These findings suggest that individuals and groups hoping to advance rural resilience in Missouri should avoid "reinventing the wheel" and instead seek existing programs and policies that could be adapted or expanded to accommodate the projected impacts of climate change.

Areas for Future Research

More research is needed that focuses on rural-specific approaches to climate change and resilience. The exploratory research conducted here highlights numerous opportunities for future research on resilience frameworks and interventions. Overall, there are three key areas we view as worthy of additional focus, (1) system-level conceptualizations of resilience, (2) effectiveness of human capital interventions, and (3) multi-stakeholder planning processes. Researchers should continue developing frameworks for system-level conceptualizations of resilience that directly connect to community capitals (e.g., Mayunga 2007; Kais and Islam 2016). Rural areas face many interrelated problems which can be studied and understood through the lens of resilience. Thus, seeking to understand the challenges and barriers involved in implementing resilience-enhancing measures and fostering resilience-

oriented communities of practice may be a fruitful area for research (Wenger 2010; Bauer et al. 2015).

Future research could also investigate the extent to which extant programs and policies for rural communities and landowners are robust to climate projections and identify opportunities for expansion and improvement. Lastly, an in depth case study of the Atchison County levee setback, and projects similar in scale and coordination, may shed light on best practices for coordinating diverse actors that could be useful for repeating collaborative resilience initiatives in other rural locations.

Limitations

Ideas and conceptualizations elicited through semi-structured interviews may be provisional, partial, spur-of-the-moment snapshots. Therefore, these results offer a preliminary glimpse into how rural leaders in a Midwestern state are thinking of climate threats, vulnerabilities, and specific steps toward more resilient communities and landscapes. The selection of interviewees also shapes the outcomes of studies such as this. Our research focused on leaders acting at the landscape scale in Missouri, but the views of actors at other levels, such as community leaders, landowners, farmers, and local public officeholders are also an important element of the broader picture in the region.

Conclusion

Many efforts to enhance rural resilience – like the Atchison County levee setback – require large-scale collaborative efforts by entities operating from a range of positions and levels within rural systems. One way to proactively prepare for changing trends is by fostering mutual understanding and trust among relevant actors and pinpointing overlapping priorities (Swyngedouw 2003; Pepermans and Maeseele 2016). Trust is among the most powerful predictors of outcomes in many situations related to natural-resource management (Stern and Baird 2015; Coleman and Stern 2018).

Our work suggests that systems-thinking proficiency may be linked to a more expansive solution set. Thus, a group of rural actors equipped with a deep understanding of one another's perspectives and interests, strong trust, and the capacity to better understanding the complex systems within which they are acting, may be better equipped to not only react to hazardous events, but to grapple with uncertainty and proactively prepare for the hazardous trends facing rural areas the world over.

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Author Contributions ZM & COB conceptualized the project with input and guidance from CC & LLS. ZM conducted all the interviews and developed the figures, COB crafted the tables, and ZM & COB jointly coded participants' responses, analyzed data, and wrote the manuscript. All authors contributed to manuscript editing.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

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