COMMENTARY

What fosters the success of a transdisciplinary environmental research institute? Reflections from an interdisciplinary research cohort

Matthew Houser[1],*, Abigail Sullivan[2], Tara Smiley[3], Ranjan Muthukrishnan[1], Elizabeth Grennan Browning[1], Adam Fudickar[1], Pascal Title[3], Jason Bertram[1], and Maria Whiteman[1]

As society confronts a multitude of wicked problems without clear solutions, transdisciplinary research institutes have the opportunity to meet the increasingly important challenge to foster research capable of addressing such problems—that is, cross-disciplinary and societally relevant research. There is a growing body of literature on how to conduct effective interdisciplinary, transdisciplinary, and team-based research, but there is less work that evaluates (1) the lessons learned, pitfalls, and successes involved in creating and maintaining transdisciplinary institutes that support this research and (2) how early-career researchers are shaped by and shape such institutes. In this commentary, we share insights and critical questions germane for those involved in the formation of, or participation in (especially as early-career, non-tenure-track researchers), transdisciplinary institutes. From our perspective as part of a unique cohort of research fellows developed as part of a new transdisciplinary institute at Indiana University, we explore facilitators and barriers to our ability to support the institute's mission. Topics addressed include tensions between research and implementation, rapidly achieving collaborative research, and community building, especially in the context of nurturing an institute with temporary employees as a key component. We reflect on what our experiences as part of such an institute mean for our career pathways, especially in the context of current academic structures and incentives. Our insights are in the context of an environmental-focused institute, but the issues raised are likely relevant to transdisciplinary institutes formed around a wide range of other themes or topics, especially those seeking to learn from the experiences of the first few years of an institute.

1. Introduction

Environmental crises, such as climate change and biodiversity loss, are fundamentally coupled-system issues, where human and environmental processes interact to (re)produce degradation and its associated risks (Liu et al., 2007). Consequently, addressing environmental issues requires knowledge about the environment and the factors impacting it, but also must involve shifting the actions of a wide range of societal actors at various levels (Lang et al., 2012). Interdisciplinary science integrates scientific knowledge across disciplines, while transdisciplinary science additionally incorporates societal perspectives into research in ways that both inform research design

and motivate outcomes and deliverables (Russell et al., 2007; Oberg, 2011; Benard and Cock-Buning, 2014). Coupled-system crises, with human–environment relationships at their core, demand transdisciplinary responses (Lang et al., 2012).

In the United States, the National Science Foundation's (NSF) *Dynamics of Integrated Socio-Environmental Systems* and *Growing Convergence Research* programs both specifically fund inter- and transdisciplinary environmental research, with the latter being identified as one of the "10 Big Ideas for Future NSF Investments" in 2016. Despite the substantial financial incentives offered by these programs and others like them, significant structural and normative barriers exist to doing inter- and especially transdisciplinary science within a traditional academic department or across departments (see Sá, 2008, for a review). This is the case even at land grant universities. Despite serving as the original model for how U.S. universities can work to address emergent, societal issues alongside community partners, declining

[1] Environmental Resilience Institute, Indiana University Bloomington, Bloomington, IN, USA

[2] Earth and Environment, Boston University, Boston, MA, USA

[3] Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY, USA

* Corresponding author:
Email: mkhouser@iu.edu

government funding has encouraged many land grants to pursue a more traditional research model (Kopp, 2021). Furthermore, disciplinary-specific science remains the guiding model structuring most faculty's work at land grant universities (Kopp, 2021; Association of Public & Land-Grant Universities, 2019). The *Kellogg Commission on the Future of State and Land-Grant Universities* (1999) succinctly illustrate this in saying, "[P]art of the issue is … society has problems, our institutions have 'disciplines'" (p. 9).

The common response to these barriers within universities has been to create new transdisciplinary research centers and institutes, which can provide the physical structure, culture, and incentives that enable multidisciplinary and applied research to rapidly emerge (Sá, 2008; Hart et al., 2016; Hoffman and Axson, 2017). Specifically considering environmental and sustainability focused centers and institutes at universities, investment in the United States exceeds US$500 million (Hart et al., 2016), and at least 20 such institutes exist across members of the Association of American Universities (Hoffman and Axson, 2017), with the majority being founded in the last 20 years. These institutes' structures, foci, strategies, and specific goals vary considerably, but they are generally united in their focus on achieving "real-world" change to address environmental/sustainability issues through collaborative research and engagement efforts (Hoffman and Axson, 2017). This points to the rapid and likely continued emergence of transdisciplinary, sustainability-focused institutes at U.S. universities.

Toward facilitating this emergence, a small but growing body of research has examined transdisciplinary research practices. One significant vein of literature focuses on the university-level and administrative barriers to undertaking inter- and transdisciplinary science (Cech and Rubin, 2004; Sá, 2008; Hoffman and Axson, 2017). Limited or unstable funding; competition with existing departments for scarce university resources; lack of top-down institutional support; a culture that rarely rewards problem-based scientific studies (i.e., applied work); achieving buy-in to the mission of the institute from faculty and students, partially related to barriers in formalizing changes to teaching and research (and how these are evaluated); and making connections with local stakeholders are among the commonly noted university-level barriers to inter- and transdisciplinary research and institute creation (National Academies of Sciences, Engineering, and Medicine, 2005; Ledford, 2015; Hart et al., 2016; Hoffman and Axson, 2017).

Even after an institute is formed, organizational or interpersonal issues that hinder transdisciplinary research may persist. Such problems have included discipline-specific terminologies preventing or limiting communication about an issue (Lélé and Norgaard, 2005; Norris et al., 2016), a "lack of respect" for social scientists' fields and methods (compared to natural scientists') reducing buy-in from the former (Ledford, 2015), and challenges with integrating or considering community-based stakeholders (Lang et al., 2012). Other studies emphasize the importance of strong institute leadership and the need for more

effective training for future leaders (Gordon et al., 2019; Boone et al., 2020). Across these studies of transdisciplinary and team science, a range of general methods, guidelines, or lessons have been offered toward overcoming these university- or team-based barriers. However, there are few articles that offer insight into the perspectives and experiences of a cohort of early-career researchers who have been tasked with conducting independent transdisciplinary research and fostering community within a nascent transdisciplinary institute.

In this commentary, we examine our own experiences as the inaugural cohort of multi- and interdisciplinary research fellows at Indiana University's (IU) Environmental Resilience Institute (ERI). Specifically, we provide practical insight into factors that have facilitated or constrained our ability to contribute to the success of a transdisciplinary, environmental institute during its initial 3 years of operation. We reflect on how the design of a transdisciplinary institute may actively help overcome barriers to promote transdisciplinary research and support the long-term success of the institute. Further, we explore how our participation in this institute has influenced our career trajectories and attitudes toward transdisciplinary research—in other words, how have we shaped the institute and how has it shaped us? In our reflections, we identify critical questions to consider for both (1) the effective design of current and future transdisciplinary, sustainability-focused institutes and (2) early-career researchers evaluating the costs and benefits of being part of transdisciplinary institutes and research. It is our hope that others in these spaces—those building or maintaining transdisciplinary institutes and early-career researchers navigating the trade-offs of transdisciplinary research—will expand this conversation with their own reactions and reflections. We begin by describing our transdisciplinary institute, the ERI.

2. Forming a transdisciplinary institute: IU's ERI
The ERI is an environmentally focused, research institution at IU Bloomington in the United States. The ERI was founded in 2017 as a component of the Prepared for Environmental Change (PfEC) Initiative, a project that received a 5-year, approximately US$38 million grant from IU's Grand Challenge program. The ERI is explicitly place-based in its research focus and outreach and implementation goals. Its mission is to enhance the resilience of the Midwest region and especially the state of Indiana (including local municipalities/communities) to the impacts of environmental change. This regional/state-level approach makes the ERI somewhat unique from many other existing environmental institutes in the United States, which most often focus their work at the global or national scale (see Hoffman and Axson, 2017). The ERI defines resilience as the ability to adapt, withstand, or transform in the face of change, and the institute focuses on resilience to environmental change, such as climate change and biodiversity loss. Institute founders were driven by a sincere desire to see research emerge that would help local people and ecosystems better withstand coming environmental

challenges, and they came to the terminology of resilience during the proposal writing process.[1]

For the purposes of this article, we define the institute's success (and our own success as institute fellows) as measured by (1) core scientific achievements, including grants and publications; (2) research implementation and outreach with relevant communities in the Midwestern United States; and (3) building a within-institute community and culture that will help carve out an enduring niche for the institute within the university. These goals are structured to align with the professional needs of individual faculty and also facilitate the long-term financial viability of the ERI.

Toward achieving research and outreach goals, PfEC principal investigators (PIs) (IU faculty and staff) began cluster-hiring tenure-track faculty, research fellows (referred to as "fellows" hereafter), traditional postdoctoral researchers, and staff. Here, we focus on our own experiences as ERI fellows. The fellows program forms an important component of the institute's structure, and the fellows are independent researchers appointed directly to the ERI, rather than an existing university department. The program was developed by the original ERI steering committee in the hopes of (1) rapidly achieving a collaborative research program at the institute and (2) establishing a unique program to foster the next generation of transdisciplinary scholars. Fellows represented a cohort of scholars who were more likely to embrace the institute's model and who had the bandwidth, given their career stage, to immediately undertake new work.[2]

The 12 fellowships began in fall 2018, equally split across the natural and social dimensions of environmental change. Our cohort included six natural scientists, two social scientists, a historian, a legal scholar, an artist, and a business scholar. Our formal university title is "Research Scientist/Scholar," which is separate from the university's classification of postdoctoral scholars. Rather than being hired onto a specific project or having a senior PI to report to, each ERI fellow is given complete autonomy to determine their research agenda and pursue new collaborations and projects. Fellows are responsible for carrying out independent research or practice programs in our areas of expertise. One of the main distinctions of the fellows program from postdoctoral research programs (many fellows were previously traditional postdoctoral researchers) is that fellows are able to serve as PIs on internal and external grant proposals. It was the hope of the ERI that we would develop collaborative projects that might lead to us applying for external grant funding, but it was not required (to-date fellows have acquired approximately US$2.5 million in external funding). We have no required teaching responsibilities, although some fellows chose to teach. Fellows also have no specific mentoring responsibilities, but many have mentored students (especially

undergraduate and master's students). Fellows were tasked with some ERI-related service (see Section 3.3 for service details in context). A subset of fellows received substantial start-up funds to be spent on research-related expenses at the fellows' discretion.

Since arriving on campus, we—the ERI fellows—have developed a unique, professional relationship across the cohort; conducted independent research; pursued a variety of novel collaborative research projects with other fellows, members of university departments, and external stakeholders; and several of us have produced practical deliverables aiming to improve the lives of the general public in Indiana and the Midwest. We have also encountered or can anticipate numerous barriers to both the success of our own work at the ERI and to the long-term functional capacity of the institute (and/or the fellows program itself). As largely early-career researchers, we have also experienced and navigated the often high and real costs of participating in transdisciplinary research to our long-term career goals. The remainder of this article is dedicated to drawing from these experiences to identify facilitators of and barriers to our ability to contribute to the success of a transdisciplinary research institute (i.e., an institute capable of supporting transdisciplinary research). In our conclusion, we give attention to our identified factors that should be considered in the (re)design of existing or future such institutes.

3. Facilitators of and barriers to transdisciplinary institute formation and the role of early-career researchers

In the following three sections, we discuss the institute-related factors that have helped or inhibited our ability to achieve individual- and institute-level goals. In the context of three areas—helping the ERI achieve research and implementation, rapidly building collaborative research, and interacting with other researchers—we consider our own experiences as ERI fellows and explore what those experiences mean for both the development of a transdisciplinary institute and for our career pursuits as early-career researchers.

As a recently established institute, our focus on our experiences during this initial period (i.e., the first 3 years of the ERI) is not meant to provide a precise template for the formation of similar institutes. Rather, we hope our experiences provide "food for thought" on (1) the role of temporary, early-career researchers in the rapid and early success of other similar, emerging transdisciplinary research institutes and (2) the trade-offs involved in pursuing transdisciplinary research in such institutes as an early-career researcher.

3.1. Achieving the ERI's transdisciplinary mission: *Research* and *implementation?*

Background and issue: Like other transdisciplinary sustainability institutes across the United States, a central component of the ERI's mission is to produce scientifically novel research—spanning the social sciences, natural sciences, and humanities—*and* engage with external partners through applied projects (Hoffman and Axson, 2017). But how we as research fellows should operate to

---

1. Thanks to Dr. Ellen Ketterson and Janet McCabe, the original and current institute directors respectively, for providing this background information.

2. Thanks to Dr. Ellen Ketterson for providing her insight on this point.

contribute to that mission is not straightforward. As the mission statement is currently expressed, the institute aspires to both conduct research and partner with communities to implement solutions to enhance environmental resilience. How can, or should, the fellows aid the institute in excelling in both research and implementation? What are the short- and long-term costs and benefits to us as early-career researchers? Will we become "Jack-of-all-trades, master of none" researchers? As fellows, we have had variable amounts of interest and success in pursuing the institute's dual missions of research and implementation. Especially initially this was shaped largely by external factors including our long-term career goals and our individual knowledge of the pitfalls and opportunities of conducting transdisciplinary research. Given that applied research is traditionally considered less prestigious and rewarded by academic culture (Sá, 2008), we expect tensions between applied and "traditional" research are common among other early-career researchers in similar institutes navigating these issues.

Facilitators: For those fellows who pursued applied projects, our early successes were considerably aided by top-down structures and actors within the institute. The presence and work of several influential individuals was key, with the ERI's past and current directors acting as political entrepreneurs to help fellows and other institute employees bridge research and implementation. Political entrepreneurs leverage their social networks, domain-related knowledge and skills, reputation, and team-building capacities to act as change agents (Christopoulos, 2006). The ERI's inaugural director (a biologist) and the current director (a lawyer) serve as visionary political entrepreneurs. The inaugural director utilized her skills and reputation as a prominent and respected scientist to facilitate relationships between university departments and across disciplines. As the former acting assistant administrator of the EPA's Office of Air and Radiation, the current director brings her extensive environmental policy experience, network of regional organizational and government contacts, and an ability to connect people with diverse skill sets to promote unique opportunities for implementation at the institute. Bottom-up efforts from the fellows and other ERI-hired faculty complemented the top-down vision instated by ERI leadership. The ERI intentionally hired fellows from multiple disciplines who had experience and/or expressed interest in applied and integrative research. Consequently, the goals of the institute's leadership largely aligned with the existing aims and interests of fellows, creating a united top-down/bottom-up pursuit of sustainability science.

The institute explicitly focuses on implementation of research as the ultimate end goal of affiliated research. As a whole, ERI had early success in achieving its related missions of research and implementation, which helped us conduct our own transdisciplinary efforts. Connections, particularly between the ERI and community partners, quickly developed within the first 2 years of the institute (such as those between Indiana mayors, other city officials, and ERI researchers and staff; e.g., see Hoosier Resilience Index, 2021). In addition to the leadership of a policy

expert (the current ERI director), this goal was made achievable through reserving funds to support the implementation manager, a full-time staff person dedicated to implementation. The implementation manager focuses on establishing connections with local communities and community organizations toward implementing research-informed tools and projects. The implementation manager helped make critical connections between the institute, the fellows, and local governments and organizations across Indiana, enabling novel research involving communities. Many (if not most) of the public deliverables achieved in the first 3 years of the institute are a result of the implementation manager's work. The success of the combined efforts of the implementation manager and a policy-practitioner director speaks to the benefits of funding such positions to work in collaboration with and in close proximity to researchers at transdisciplinary institutes. The fellows' efforts to conduct transdisciplinary research benefited from the connections formed by the implementation manager. Specifically, several of us established research projects that directly involved, and in some cases were codesigned with, community partners first connected to the institute by the implementation manager (e.g., see Hoosier Life Survey, 2021). If we had not been able to leverage the social capital of the individual in this position, we feel our efforts to form community partnerships would have been far less successful, especially given our relatively short-term appointments, which limits capacity to build trust with community organizations, and pressures to produce disciplinary achievements (see below).

It is well established that engaging in transdisciplinary research in the current academic system is costlier in terms of time investment (O'Neill et al., 2019), which can disincentivize researchers—especially early-career researchers. The fellows do not have teaching responsibilities and were given regular access to opportunities to share our research beyond the confines of academic publications (e.g., meeting with science communicators or the staff of respected popular science outlets like The Conversation). These factors additionally facilitated our ability to increase our research impact (e.g., several fellows wrote op-eds for the general public, participated in science communication events, and conducted research centered on the goals of community partners).

Barriers: Tensions between the (1) research and implementation pieces of the ERI's mission and (2) what is valued by broader academic culture have impacted our ability to achieve transdisciplinary research and support the institute's mission. First, members of the ERI community have articulated uncertainty about how the institute defines its purpose. Some institute affiliates (e.g., some staff and community members) view the institute as operating like a traditional environmental nonprofit focused primarily on working with communities and other partners to engage in implementation, education, and outreach. Other affiliates (e.g., some faculty) have noted concern as the ERI attempts to fulfill both the roles of supporting academic research and focusing on outreach efforts that do not always directly involve the research produced by ERI affiliates. As fellows, we noticed these

tensions, and they led us to question how to allocate our time between traditional scholarly activities (e.g., peer-reviewed journal articles and manuscripts) and outreach valued by the ERI (e.g., op-eds). For example, throughout the first year of our positions, we explicitly discussed whether we should write op-eds or policy briefs at all and whether we should prioritize this type of work potentially at the expense of academic manuscripts. Several of the fellows did write individual and/or collaborative op-eds, but for some of us, the time-cost for this type of work has been too great, especially as we pursue permanent positions elsewhere.

As a cohort, we all came to different conclusions about the costs and benefits of contributing to research and implementation depending partially on our career goals and recognizing the costs of transdisciplinary research *in the current academic system*. Fellows were not provided explicit requirements on either the types of activities we should engage in or how much time to devote to these activities. In the absence of formal requirements, some fellows reverted to disciplinary research that we are more familiar with (less costly to initiate). Several of us are pursuing tenure-track positions, and our experience tells us disciplinary research is often more valued by much (if not most) of the tenure-track job market. Even though the institute intentionally hired fellows and other faculty who were experienced in transdisciplinary research and/or expressed interest in it, this did not always prevail over the broader academic culture that still largely incentivizes disciplinary research, especially for early-career researchers seeking tenure-track positions. Essentially, if applied work will not be valued by a desired future employer, dedicating resources to it now may prevent the achievement of a future career goal as defined by existing academic cultures. The tension generated by doing work that is valued by the institute (and supports its mission), but less valued by the standard academic job market, is therefore a central and pervasive barrier to the ERI's success, and we expect it is for many other transdisciplinary sustainability institutes as well.

Looking ahead: It remains to be seen to what degree supporting research and implementation efforts can be achieved in the long term at the ERI, given its infancy. As Hoffman and Axson's (2017) survey of interdisciplinary sustainability institutes at research universities suggests, the ERI may benefit from conversations with on and off-campus communities to promote transparency and clear definitions of how the ERI envisions its future goals and what success will mean. In addition, infrastructure should continue to be developed and supported for data generation (e.g., super computing resources), management (e.g., database development), and sharing, especially in engaging and interactive formats tailored to the end users' implementation goals (e.g., see FutureWater, 2021). Practical tools and personnel dedicated to the development and implementation of researcher–user interfaces have already achieved transdisciplinary outcomes at the ERI. Constructive and iterative feedback from community- and state-level stakeholders can ideally focus and expand researchers' efforts and data output in ways that support both traditional academic and implementation goals.

Finding strategies that mitigate tensions between short- and long-term career goals is also necessary, for the ERI and other like-minded institutes, if affiliated researchers, including temporary employees such as fellows, are to fully dedicate themselves to research *and* implementation.

In addition to actively changing the norms of academia, could explicitly providing opportunities to prepare for and pursue nonacademic scientific careers be important to reconciling tensions between what academia currently values (disciplinary work) and the success of transdisciplinary institutes? This could be achieved, in part, through focusing on connecting institute fellows with local industry, government, or nonprofits via partnerships and collaborative projects where working relationships resembling quasi-internships could form. At least for some fellows, such efforts could diminish concerns about finding future academic employment and enable them to go "all in" on applied, transdisciplinary work (that aims to produce more than journal articles). The long-term success of a transdisciplinary institute like the ERI may be better supported if the university invested in permanent, full-time research scientists (i.e., if the fellows' positions were not temporary).

3.2. Rapidly achieving cross-disciplinary, collaborative research

Background and issue: Achieving cross-disciplinary, collaborative research between fellows and affiliated faculty, and especially developing successful grant proposals, was noted as a key outcome to achieve within the ERI's initial 5-year funding period. Although we were not required to submit external proposals, the ability to serve as PI on external proposals was a major draw of the fellow position for many of us, for our own career goals. Additionally, the acquisition of external grants are key means through which many inter/transdisciplinary institutes financially support themselves, and such achievement would potentially promote future investments by the university and wider community (Hoffman and Axson 2017). Yet, connecting and communicating across disciplinary divides is one of the major challenges to doing inter- and transdisciplinary research (Pickett et al., 1999; Guise et al., 2017) and therefore a barrier to successful proposal development. While individual dynamics certainly matter for whether and to what extent these connections develop, intentional institutional practices can help to promote the emergence of collaborations between scholars. For the ERI, what practices facilitated the emergence of cross-disciplinary, collaborative research among our cohort of fellows and between ourselves and other collaborators?

Facilitators: ERI fellows are unique among most post-doctoral researchers in that we apply for grants as full project PIs and were given autonomy to determine our research agendas. Upon being hired, some fellows were introduced to preexisting working groups of tenure-track faculty and/or institute leadership (which we were encouraged to participate in, but not directed to). These dual programmatic features—providing autonomy, yet also opportunities to engage in ongoing collaborations—were conjointly important to promoting further collaborative

efforts, especially for proposal writing. Our autonomy ensured that true enthusiasm for the people and the ideas behind new proposals drove our interest and participation, which fostered our commitment to transdisciplinary projects. Although not all current or future institutes may be capable of offering such autonomy to their researchers, our experiences speak to the benefits of offering at least some autonomy when possible.

A number of collaborative proposals and projects were developed exclusively between fellows (including this very article). Being of equal professional rank (i.e., all fellows) reduced the potential for power dynamics to emerge that could create disincentives to holding honest conversations (i.e., the traditional academic hierarchy was leveled). From our experiences, being able to be open and honest about concerns or points of confusion (1) directly facilitates transdisciplinary conversations, which are notably difficult to navigate (O'Rourke and Crowley, 2013), and (2) builds social capital (i.e., the strength of relationships; Dekker and Uslaner, 2003) that can foster future collaborations (Mountford et al., 2019). This points to the benefits of bringing in cohorts (three or more) of multidisciplinary, equal-rank researchers when possible.

Additionally, and not surprisingly, frequent in-person and planned meetings were important to developing relationships between the fellows. The fellows hold biweekly "fellows meetings" to discuss formal agenda items. But these meetings also function as a space for casual conversation. Both the semi-casual style of these meetings and their regular occurrence facilitated the emergence of diverse topics, such as potential research ideas, and supported the creation of social capital among us, leading to a number of transdisciplinary project proposals (e.g., see Midwestern Aquatic Invasive Species, 2021; Hoosier Lifelines, 2021). Monthly casual "coffee and donut" meetings (formally titled "Climate Conversations")—which were open to all and often included affiliated faculty and external partners (e.g., U.S. Geological Survey members)—also served to connect us to other existing efforts to address climate change. These meetings were supported by crucial institute financial investments in staff who helped with logistics like event space. Finally, a call for an internal pilot-grant was announced during our first year and worked as a catalyst that motivated us to capitalize on the emerging building blocks of transdisciplinary collaborations. This initial call funded several collaborative projects among the fellows including the one on invasive species (Midwestern Aquatic Invasive Species, 2021) "and one on [isotopic] approaches to investigating changing bird migration" (Isotopic Studies of Animal Migrations, 2021).

Barriers: The independent nature of the fellows program is one aspect that attracted many of us to the institute. The balance between maintaining that independence and directly contributing to existing projects and programmatic aims is a challenge we faced and will likely continue to experience. Although we rapidly developed a tight-knit group and made numerous connections with ERI faculty and community partners, our efforts to establish connections with researchers located in other units of the university proved difficult in many cases. The institute attempted to integrate us within traditional departments through adjunct faculty appointments in our respective disciplinary homes. The impact of these formal associations was mixed. In some cases, the unique transdisciplinary, environmental focus of some of our research agendas limited the capacity for this appointment to be anything more than a label, as there was limited connection between our work and some departments' major research and teaching interests. In particular and not unsurprisingly, the more transdisciplinary a fellow's work was, the less likely they were to develop strong connections within a home department.

Similar to other institutes (Hoffman and Axson, 2017), the limited incentives for noninstitute faculty to seek collaborative efforts with institute fellows and researchers, especially given the tension between transdisciplinary research and traditional department evaluation criteria, limited our ability to more fully integrate our work across the university (e.g., within many university departments). This divide between the ERI and university departments was especially noticeable to some of us as we applied for various external grants. A potential solution could be more top-down support (cultural and financial) from the university to ensure traditional departments benefit from collaborating with us as ERI researchers.

Looking ahead: The institute is taking seriously the need to promote both internal and external institutional collaborations and connections. Institute leadership, as well as many of the fellows, is actively considering how to position themselves and the institute in such a way that it becomes more inclusive and inviting for nonassociated faculty and how to better integrate the fellows with the broader university community. Given many ERI researchers' unique focus on implementation, framing the institute as the place at IU for novel, yet applied environmental research may support the longevity of the institute as more attention is paid to outreach and community deliverables in major federal grants.

As noted, the autonomy provided to us was/is beneficial in a number of ways, and we think it should be considered by other institutes. Yet this autonomy may need to be more structured moving forward to ensure our work builds toward achieving longer term institutional/societal goals. Goal-based strategic planning could potentially serve to bridge our autonomous pursuits and the institute's long-term goals. The University of Minnesota's Institute on the Environment, for instance, pursues tangible, specific goals (e.g., "Build a Carbon Neutral Minnesota"). This planning strategy provides clear ends to pursue but does not necessarily determine the means to get there. Adopting this strategic planning approach in tandem with an independent fellowship program could support the creativity and energy that autonomous and self-motivated researchers can offer without sacrificing an institute's capacity to pursue consistent and clear long-term goals.

3.3. Building a community: The trade-offs of being temporary employees
Background and issue: The ERI employs university faculty and staff with widely different career stages and roles,

including administrative staff, implementation staff, full-time research associates and technicians, postdoctoral research associates, fellows, and tenure-track/tenured faculty. Partially because the ERI exists within the confines of a university system, there are obvious and sometimes challenging disparities in the responsibilities of and incentives for people with different roles and career stages to be actively involved in the ERI community. The ERI fellows are directly appointed to the institute without required teaching responsibilities, unlike tenure-track faculty who were also hired as part of the Grand Challenge initiative (and also unlike the fellows/affiliates of many other such institutes; Hoffman and Axson, 2017). As a result, the fellows have different service responsibilities largely focused around ERI community building. In line with the independent spirit of the overall position, the fellows were not given specific ERI service responsibilities. However, the ERI leadership suggested (1) we develop a fellows-managed seminar series open to the university community and general public, and (2) we establish other activities that could facilitate community building within the ERI and between the ERI and the broader university.

Transdisciplinary environmental institutes, including the ERI, live and die based on the voluntary participation of university faculty, staff, administration, and community partners. Ensuring the continued existence of the institute depends on creating a wide-reaching community of scholars and practitioners, as well as a stellar reputation. But what does it mean for the future of an institute to have temporary employees like us responsible for important pieces of the institute's community building and the research pursued within the institute? How does this impact fellows' and the institute's ability to integrate with the wider university?

Facilitators: We have contributed to activities that help maintain the institute's sense of community, including organizing the annual fall research symposium, establishing and maintaining an invited-speaker seminar series, and hosting a monthly networking "Climate Conversations" event. We started organizing these events shortly after our appointments began, which helped build social capital among ourselves, but also between ourselves and other members of the ERI and university communities. Events like the invited speaker series and fall symposium have been well attended by the broader ERI community, and people have noted feeling more connected to the ERI via these events. The extra-departmental placement of the ERI also allows these events to be broader and encourage a less parochial audience than might be the case within a traditional department.

Barriers: An institute focused on "wicked" problems that require input from many perspectives and expertise (that often proceed in isolation) faces inherent challenges to impactful action. Barriers to the formation of a sustained and united community working toward such goals at the ERI include reliance on nonpermanent faculty and personnel (like ourselves) to strengthen a community that they are likely to depart in the future. The push and pull of investment in institutional community building and the pressure felt by many of us to find permanent positions creates an incentive conflict for us as largely early-career researchers. Because we work within the confines of existing academic culture, we are continuously aware of the trade-offs. The time we invest in community building may hurt us later, both in terms of being connected to a community we must depart and in terms of reducing time for activities that may be more likely to help us secure permanent employment.

Additionally, several of us feel that it is sometimes a struggle to balance the intellectual freedom we have been given to pursue our research agendas with the ways in which the temporary nature of our position affects our ability to start and maintain our research projects and connections with other faculty, especially potentially more time, energy, and resource intensive transdisciplinary ERI-related research. Most notably, it takes time with community partners to earn their trust and realize their applied goals. Term-limited fellows lack not only time, but most of us had limited experience/training in participatory research practices. While some science communication training was provided and as noted above, full-time ERI staff provided guidance and connections, these issues still hindered (but certainly did not prevent) the development of fellow-external partner collaborations.

Looking ahead: In large part, the challenges of us fully contributing to the institute's mission and achieving our own professional goals are directly tied to the temporary nature of our positions. Tensions between participating in ERI-related service and research are particularly acute for those of us who are pursuing tenure-track positions because we are incentivized by the existing academic culture to focus the majority of our efforts on research (an apparent zero-sum game between service and research). If the fellows program substantially changes in the future (e.g., it is smaller or does not exist), can the ERI structure or influence university incentives such that service supporting the ERI community is more rewarded among other types of staff and faculty? What if universities creating transdisciplinary institutes considered creating permanent (as opposed to temporary) research scientist positions that would also be responsible for service activities to build social capital within the institute's community and between the institute and community partners? The ERI is not alone in facing these types of challenges.

If these barriers are addressed, initial investments in the ERI could have wide-reaching benefits for both the temporary employees of such institutes and the broader university and surrounding community. Transdisciplinary institutes such as the ERI remain the central medium for scholars in traditional university departments to pursue applied research, which is one of the most promising means of addressing environmental crises (Hart et al., 2016).

4. Conclusions and opportunities moving forward

As the importance of establishing transdisciplinary research institutes capable of addressing society's

problems continues to increase, the need for studies assessing the factors that support or limit their initial and long-term success intensifies. Although IU's ERI is relatively new, several insights have emerged related to our experiences as early-career researchers and our ability to (1) support the ERI in achieving transdisciplinarity, (2) rapidly establish cross-discipline and collaborative research among our cohort and other faculty, and (3) build and maintain within-university and within-institute relationships while pursuing permanent employment. Looking across these areas, social capital (i.e., trusting, strong relationships), particularly among ourselves and between ERI faculty and staff and nonuniversity, community partners, was a key facilitator of all three. A common barrier to us as largely early-career researchers was a mismatch between the institute's transdisciplinary mission and traditional university institutions that limit incentives to engage in longer term transdisciplinary research and community building. To assist with the development of the facilitators and to overcome the barriers that we have outlined, other institutes and other early-career researchers navigating the trade-offs of transdisciplinary research may consider the following questions and suggestions.

4.1. Hiring considerations in transdisciplinary institutes

As noted, the dual features of autonomy and opportunities to join ongoing collaborations helped ERI fellows achieve rapid transdisciplinary research initiatives. However, the finite and autonomous nature of the ERI fellow position creates some barriers to the long-term success of the ERI. Would fewer, but more permanent positions, be more effective? What will be the role of temporary faculty (including fellow-type positions) in developing research and conducting service? Should other transdisciplinary institutes try to establish fellows' programs similar to that of the ERI's model?

One potential hiring model could focus on achieving applied sustainability goals while training the next generation of transdisciplinary researchers for nonacademic positions. A small staff of permanent applied research scientists and dedicated implementation staff (e.g., the ERI implementation manager) could undertake consistent and applied work over time while simultaneously mentoring and training cohorts of annual fellows who could bring transdisciplinary and applied expertise to nonacademic environmental positions. Traditional departments continue to train PhDs largely for careers in academia despite the dramatic shortfall of academic jobs for PhDs (McKenna 2016). Such an approach to institutional staffing could promote long-term achievement and help the institute to serve, rather than compete with, existing university departments (Hoffman and Axson, 2017). Several of the ERI fellows have felt that a position as a permanent, applied researcher at a transdisciplinary university institute is their ideal career, if only it widely existed. Notably, land grant universities already employ faculty with Extension appointments. Although these positions serve as a precedent for permanent, applied research/implementation dedicated scientists at universities, they are not synonymous with what we are proposing. Extension faculty are generally tenure-track in a specific department. Their research activities may then be guided by the same disciplinary constraints that shape the activity of other non-Extension faculty (Sá, 2008). A permanent position rank of applied scientist at a transdisciplinary institute could more directly foster transdisciplinary work and help to overcome the discussed barriers associated with term-limited work on societal, environmental issues.

4.2. How did the ERI shape the fellows and our career pathways?

The ERI fellows have consistently struggled with the trade-offs associated with contributing to the community and mission of a transdisciplinary institute. Some of us—depending on how disciplinary we were when we started our ERI positions and the norms of our respective fields—were more constrained and less incentivized to engage in transdisciplinary work from the beginning. These pressures are/were especially acute for those of us pursuing tenure-track positions. Our capacity to practice applied research is constrained partially by a need to market ourselves as belonging to a traditional discipline (e.g., biology, sociology, history) such that we "fit" into existing academic departments, which largely remain siloed. Some of us have struggled on the job market in our respective disciplines for exactly this reason; we are "too broad" or no longer "fit" a department's idea of a "fill-in-the-blank" scholar. In our experience, there is a kind of "goldilocks principle" for engaging in transdisciplinary research as an early-career researcher pursuing a tenure-track position. Current academic culture incentivizes us to be somewhere in the middle—engaging in applied research that matters to the ERI and is of interest to us, but not going so far that we no longer fit a traditional discipline. Further, some of us have experienced personal changes in our own values during our time at the ERI. At least, the most disciplinary of us have come to value the way the ERI has pushed us outside of our research comfort zones and at most, some of us have developed a different relationship with our field and no longer see disciplinary academic departments that devalue research addressing broader societal issues as appropriate for us. In other words, some of us want to be part of the academy but are unfulfilled by traditional academic culture.

Although our experiences on the academic job market have been diverse—which is unsurprising in such a large and diverse cohort—several of the ERI fellows have already moved on to tenure-track academic positions in the natural sciences, social sciences, and law (and others were offered, but declined, such positions). The ability to be the PI on grant proposals and the general autonomy of our positions at the ERI provided many of us the opportunity to essentially gain a head start on running our own labs, research programs, or other equivalent academic endeavors. We were able to adjust to some of these often-intimidating career-stage changes earlier than we would have without the ERI fellows program. In our new positions, some of us continue to navigate the trade-offs of pursuing transdisciplinary research and how we will be

evaluated by our departments and disciplines when we pursue promotion.

Considering our experiences, we suggest that people designing or modifying transdisciplinary institutes ask: how are fellows-type programs pathways to subsequent tenure-track academic positions and perhaps more importantly, *should they be*? Again, we wonder how the tensions and trade-offs we have experienced as fellows at a transdisciplinary institute could be radically different if there were more permanent research positions at universities to support the research and community building of transdisciplinary institutes. Will universities ever be willing to make this type of investment broadly in transdisciplinary research and specifically in full-time, permanent (i.e., not soft money) research faculty? U.S. academic culture is slowly beginning to recognize the value of transdisciplinary research—some of our post-ERI academic positions in unique departments support this. But will it change fast enough that other early-career transdisciplinary researchers are not forced out of either applied research or academia all together?

Other pertinent questions include the following: Can transdisciplinary institutes (especially if not yet formed) influence or make agreements with the university for how evaluation criteria (including hiring) might be altered for faculty involved with an institute? Can incentives be restructured to explicitly value transdisciplinary efforts? Could outreach like op-eds count as a portion of research output? Can people involved with the formation of an institute secure evaluative options for faculty following a diversity of tracks to achieve inter- and transdisciplinary research? (For an example, see the evaluation rubric developed by the ERI fellows for their own annual evaluations in the Supplemental Materials.)

We have learned from our own experiences as part of the ERI and other such institutes that there is often a desire for information on both how early-career researchers navigate these endeavors and broader "how-to" lessons for institutes. The facilitators, barriers, lessons, and questions we have discussed reflect our own experiences as ERI fellows, but likely apply to other environmental-focused institutes and may translate to cross-cutting domains such as health or technology. Precisely how these considerations and lessons vary across diverse domains is an empirical question that remains to be answered. Consequently, we also call for additional commentaries, reflections, and analyses from other similar transdisciplinary university research institutes, and especially from other early-career and non-tenure-track researchers at such institutes. The more we are willing to openly analyze and reflect on the pitfalls and successes we have encountered in attempting to pursue transdisciplinary research and establish or maintain such institutes, the more opportunity future endeavors have to design institutes that will be successful in the short and long term. By connecting science to public practice, transdisciplinary institutes play a critical role in averting the worst of our various and interrelated crises (e.g., environmental, health, inequality). We must then rapidly come to a better understanding of (1) how to successfully design and implement these university-based institutes and (2) how to incentivize transdisciplinary researchers if we are to achieve necessary societal change.

Supplemental file
The supplemental file for this article can be found as follows:

Fellows' Evaluation Document. PDF

Competing interests
The authors declare no competing interests.

Author contributions
Matthew Houser and Abigail Sullivan contributed equally and are alphabetical.

Contributed to conception and design: MH, AS, TS, RM, EGB, AF, PT, JB, MW.

Drafted and/or revised the article: MH, AS, TS, RM, EGB.

References
Association of Public & Land-Grant Universities. 2019. Public impact research: Engaged universities making the difference. Available at https://www.aplu.org/library/public-impact-research-engaged-universities-making-the-difference/file. Accessed 10 April 2021.

Benard, M, de Cock-Buning, T. 2014. Moving from monodisciplinarity towards transdisciplinarity: Insights into the barriers and facilitators that scientists faced. *Science and Public Policy* **41**(6): 720–733. DOI: http://dx.doi.org/10.1093/scipol/sct099.

Boone, CG, Pickett, ST, Bammer, G, Bawa, K, Dunne, JA, Gordon, IJ, Mallee, H. 2020. Preparing interdisciplinary leadership for a sustainable future. *Sustainability Science* **15**: 1723–1733.

Cech, TR, Rubin, GM. 2004. Nurturing interdisciplinary research. *Nature Structural & Molecular Biology* **11**(12): 1166–1169. DOI: http://dx.doi.org/10.1038/nsmb1204-1166.

Christopoulos, DC. 2006. Relational attributes of political entrepreneurs: A network perspective. *Journal of European Public Policy* **13**(5): 757–778. DOI: http://dx.doi.org/10.1080/13501760600808964.

Dekker, P, Uslaner, EM eds. 2003. *Social capital and participation in everyday life* (vol. 23). London, UK: Routledge.

FutureWater. (2021). *Future Water*. Earth and Atmospheric Sciences, Indiana University. Available at https://futurewater.indiana.edu.

Gordon, IJ, Bawa, K, Bammer, G, Boone, C, Dunne, J, Hart, D, Taylor, K. 2019. Forging future organizational leaders for sustainability science. *Nature Sustainability* **2**(8): 647–649.

Guise, J-M, Winter, S, Fiore, SM, Regensteiner, JG, Nagel, J. 2017. Organizational and training factors that promote team science: A qualitative analysis and application of theory to the National Institutes of Health's BIRCWH career development program. *Journal of Clinical and Translational Science* **1**(2): 101–107. DOI: http://dx.doi.org/10.1017/cts.2016.17.

Hart, DD, Buizer, JL, Foley, JA, Gilbert, LE, Graumlich, LJ, Kapuscinski, AR, Kramer, JG, Palmer, MA, Peart, DR, Silka, L. 2016. Mobilizing the power of higher education to tackle the grand challenge of sustainability: Lessons from novel initiatives. *Elementa: Science of the Anthropocene* **4**. DOI: http://dx.doi.org/10.12952/journal.elementa.000090.

Hoffman, AJ, Axson, J. 2017. *Examining interdisciplinary sustainability institutes at major research universities: Innovations in cross-campus and cross-disciplinary models (SSRN Scholarly Paper ID 2961860)*. Social Science Research Network. DOI: http://dx.doi.org/10.2139/ssrn.2961860.

Hoosier Lifelines. 2021. *Environmental and social change in Indiana*. Environmental Resilience Institute, Indiana University. Available at https://eri.iu.edu/research/communication-education-and-outreach/hoosier-lifelines.html.

Hoosier Life Survey. 2021. *Documenting Hoosier attitudes*. Environmental Resilience Institute, Indiana University. Available at https://eri.iu.edu/research/human-impacts-and-attitudes/hoosier-life-survey.html.

Hoosier Resilience Index. 2021. *Evaluate your risks and learn how to prepare*. Environmental Resilience Institute, Indiana University. Available at https://hri.eri.iu.edu.

Isotopic Studies of Animal Migrations. 2021. *Understanding species vulnerability and resilience*. Environmental Resilience Institute, Indiana University. Available at https://eri.iu.edu/research/wildlife/isotopic-studies-of-animal-migrations.html.

Kellogg Commission on the Future of State and Land-Grant Universities. 1999. *Returning to our roots: The engaged institution*. National Association of State and Land-Grant Colleges and the Kellogg Foundation. Available at https://www.aplu.org/library/returning-to-our-roots-the-engaged-institution/file. Accessed 31 May 2021.

Kopp, R. E. (2021). Land-grant lessons for Anthropocene universities. *Climatic Change* **165**(1): 1–12.

Lang, DJ, Wiek, A, Bergmann, M, Stauffacher, M, Martens, P, Moll, P, Swilling, M, Thomas, CJ. 2012. Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science* **7**(1): 25–43. DOI: http://dx.doi.org/10.1007/s11625-011-0149-x.

Ledford, H. 2015. Team science. *Nature* **525**: 308.

Lélé, S, Norgaard, RB. 2005. Practicing interdisciplinarity. *BioScience* **55**(11): 967–975.

Liu, J, Dietz, T, Carpenter, SR, Alberti, M, Folke, C, Moran, E, Pell, AN, Deadman, P, Kratz, T, Lubchenco, J, Ostrom, E, Ouyang, Z, Provencher, W, Redman, CL, Schneider, SH, Taylor, WW. 2007. Complexity of coupled human and natural systems. *Science* **317**(5844): 1513–1516. DOI: http://dx.doi.org/10.1126/science.1144004.

McKenna, L. 2016. The number of Ph.D.s keeps rising despite bad job numbers. *The Atlantic*. Available at https://www.theatlantic.com/education/archive/2016/04/bad-job-market-phds/479205/.

Midwestern Aquatic Invasive Species. 2021. *Studying aquatic invasive species*. Environmental Resilience Institute, Indiana University. Available at https://eri.iu.edu/research/pests-and-invasive-species/what-will-midwestern-aqautic-invasions-look-like.html.

Mountford, N, Coleman, M, Kessie, T, Cusack, T. 2019. Interdisciplinary doctoral research networks: Enhancers and inhibitors of social capital development. *Studies in Higher Education*. DOI: http://dx.doi.org/10.1080/03075079.2019.1623768.

National Academies of Sciences, Engineering, and Medicine. 2005. *Facilitating interdisciplinary research*. DOI: http://dx.doi.org/10.17226/11153.

Norris, PE, O'Rourke, M, Mayer, AS, Halvorsen, KE. 2016. Managing the wicked problem of transdisciplinary team formation in socio-ecological systems. *Landscape and Urban Planning* **154**: 115–122. DOI: http://dx.doi.org/10.1016/j.landurbplan.2016.01.008.

Oberg, G. 2011. *Interdisciplinary environmental studies: A primer*. West Sussex, UK: John Wiley & Sons.

O'Neill, M, Adams, MP, Bandelt, MJ, Chester, SA, Cai, W, Nadimpalli, SP. 2019. Cohort learning: Supporting transdisciplinary communication and problem-solving skills in graduate STEM researchers. *International Journal of Teaching and Learning in Higher Education* **31**(1): 166–175.

O'Rourke, M, Crowley, SJ. 2013. Philosophical intervention and cross-disciplinary science: The story of the Toolbox Project. *Synthese* **190**(11): 1937–1954. DOI: http://dx.doi.org/10.1007/s11229-012-0175-y.

Pickett, STA, Burch, WR, Grove, JM. 1999. Interdisciplinary research: Maintaining the constructive impulse in a culture of criticism. *Ecosystems* **2**(4): 302–307.

Russell, AW, Wickson, F, Carew, AL. 2008. Transdisciplinarity: Context, contradictions and capacity. *Futures*, **40**(5), 460–472. DOI: http://dx.doi.org/10.1016/j.futures.2007.10.005.

Sá, CM. 2008. 'Interdisciplinary strategies' in U.S. research universities. *Higher Education* **55**(5): 537–552. DOI: http://dx.doi.org/10.1007/s10734-007-9073-5.

ELEMENTA
Science of the Anthropocene

Elem Sci Anth is a peer-reviewed open access journal published by University of California Press.

OPEN ACCESS