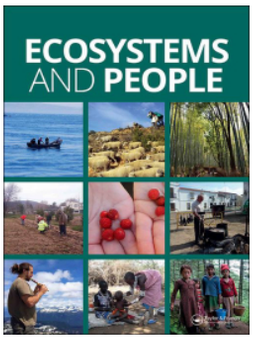

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The programme on ecosystem change and society (PECS) – a decade of deepening social-ecological research through a place-based focus

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PERSPECTIVE: TEN YEARS OF THE PROGRAM ON ECOSYSTEM CHANGE AND SOCIETY

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The programme on ecosystem change and society (PECS) – a decade of deepening social-ecological research through a place-based focus

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ABSTRACT

The Programme on Ecosystem Change and Society (PECS) was established in 2011, and is now one of the major international social-ecological systems (SES) research networks. During this time, SES research has undergone a phase of rapid growth and has grown into an influential branch of sustainability science. In this Perspective, we argue that SES research has also deepened over the past decade, and helped to shed light on key dimensions of SES dynamics (e.g. system feedbacks, aspects of system design, goals and paradigms) that can lead to tangible action for solving the major sustainability challenges of our time. We suggest four ways in which the growth of place-based SES research, fostered by networks such as PECS, has contributed to these developments, namely by: 1) shedding light on transformational change, 2) revealing the social dynamics shaping SES, 3) bringing together diverse types of knowledge, and 4) encouraging reflexive researchers.

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Introduction

In a time of fast-moving social and ecological change, humanity's ability to create a better future depends on understanding the local, regional and global interactions of humans and nature (Nunn et al. 2014; Epstein et al. 2015; Folke et al. 2021). Research on social – ecological systems (SES) has helped to foster

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this understanding, and to guide scale-appropriate action (Ostrom 2009; Reyers et al. 2018). SES research is a branch of sustainability science that focuses on integrated systems of humans and nature. While SES research perspectives are of relevance at multiple scales, the roots of diversity, innovation, and the details of solutions, are typically local and place-based. Place-based SES research that addresses the unique social-ecological dynamics of specific cities, landscapes, seascapes or coastal regions, has helped to develop new knowledge and approaches.

The Programme on Ecosystem Change and Society (PECS) was established in 2011, as a 10-year initiative within the International Council for Science, and transitioned to the global Future Earth network[1] in 2014 (Carpenter et al. 2012; Norström et al. 2017). PECS is a network of place-based, social-ecological research from around the world, that has brought together academics (from different disciplines) and people from various sectors (e.g. from government, business, civil society, local and Indigenous communities) to generate knowledge and catalyze change. Two international conferences in South Africa (2015) and Mexico (2017), five academic special issues (Norström et al. 2017; Seppelt et al. 2018; Martín-López et al. 2020), a series of international workshops, and a rapidly growing number of research projects, working groups, and regional nodes have positioned PECS as one of the major international SES networks of the past decade. Close connections to the growing number of other initiatives that are fostering and coordinating solution-oriented and place-based SES research have been actively nurtured (Balvanera et al. 2017a). A feature of PECS has been its comparative approach, which has magnified insights from many place-based SES research projects to inform and inspire global sustainability research and practice (Oteros-Rozas et al. 2015; Fischer et al. 2015; Balvanera et al. 2017c; Castro et al. 2018; Norström et al. 2020).

While PECS has continued to grow, the world has been undergoing rapid change. Sustainability challenges have intensified, including continuing biodiversity loss, climate change, and social inequality (Hamann et al. 2018; Díaz et al. 2019; Brondizio et al. 2019; Lenton et al. 2019). At the same time, however, glimpses of a more sustainable future are also becoming more visible. For example, the Seeds of a Good Anthropocene project is collecting, curating and analyzing a growing database of local sustainability initiatives that have the potential to inspire broader change (Bennett et al. 2016). We are seeing some evidence that people's values are changing to favor environmental transformation. For example, in the western United States attitudes towards wildlife have changed in ways that may signal positive news for sustainability more broadly (Manfredo et al. 2021). Indeed, around the world, societies are exploring different types of social innovations in search of a better future, and solutions from the global south are particularly inspiring (Nagendra 2018; Carpenter et al. 2019).

Despite these bright spots of optimism, the turbulence and urgency of the current situation remains apparent. Calls for transformations that can shift human development onto more sustainable pathways, are no longer at the margins of science, policy and practice (Leach et al. 2018; Köhler et al. 2019; Dasgupta 2021). It is telling that the second decade of PECS will coincide with the UN Decade of Action, an ambitious global effort that aims to deliver strong and transformative progress across all Sustainable Development Goals (SDGs) by 2030. The SDGs were developed to be 'integrated and indivisible', in order to balance the three dimensions of sustainable development – economic, social and environmental. SES research highlights that human economies and societies are embedded parts of the Biosphere. A resilient Biosphere provides the life support systems upon which prosperity, human wellbeing and sustainable development ultimately rest. Transformations towards biosphere-based sustainability cannot be achieved by incremental change alone (Reyers et al. 2018).

In this Perspective, we reflect that SES research has deepened over the past decade, and helped to shed light on key dimensions of SES dynamics (e.g. system feedbacks, aspects of system design, goals and paradigms) that may be overlooked in global assessments, and that can lead to tangible action for solving the major (global) sustainability challenges of our time. We suggest that the growth of place-based SES research, fostered by networks and initiatives such as PECS, has contributed to these developments. This is not an exhaustive review and systematic survey of the entire SES research field. While we tap into insights from the broader place-based SES literature from the past decade, our focus is on research affiliated to PECS (i.e. stemming from past and/or ongoing PECS working groups, projects and regional networks), and our own experiences as researchers embedded in the field.

Deepening of SES research through place-based research

The past decade has seen a phase of rapid growth of SES research, and an increased pluralism and diversity in the types of issues being addressed (Colding and Barthel 2019; de Vos et al. 2019). At the same time, SES research has had an enhanced influence on broader sustainability science, practice and policy (Fischer et al. 2015). Importantly, in addition to these advances, SES research has also deepened over

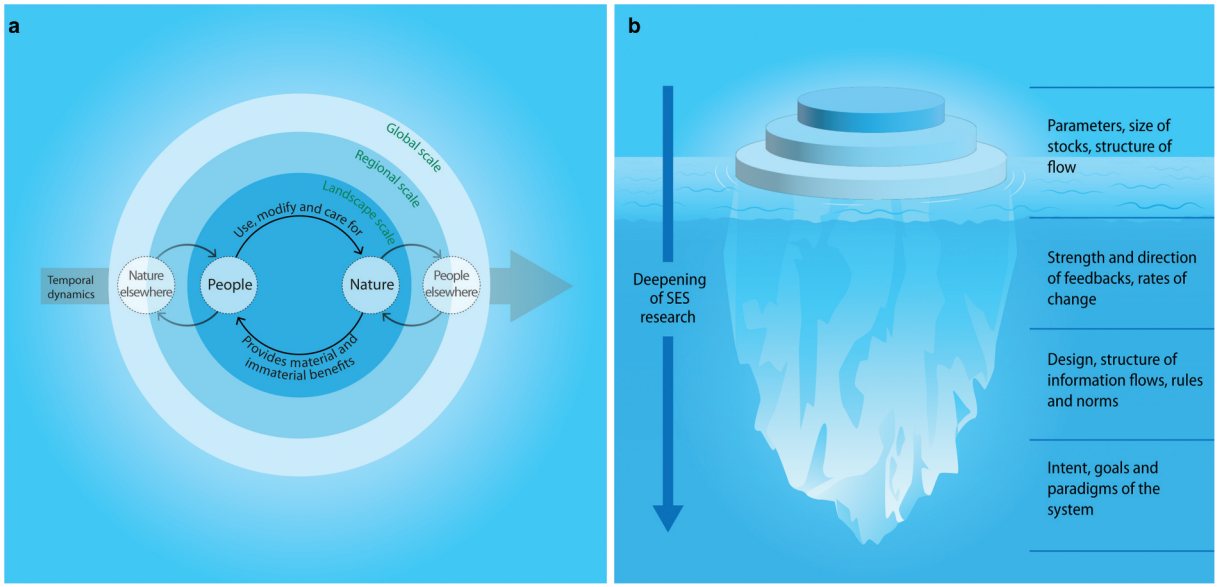

Figure 1. Panel a shows a traditional social – ecological systems (SES) framework that highlights how SES are interdependent and linked systems of people and nature, which are nested across scales and play out against a backdrop of global change and other temporal dynamics (adapted from Fischer et al. 2015). Panel b conceptualises an SES as an iceberg. If viewed from above, only the tip of the iceberg is visible, and this represents key parameters, variables and feedbacks of an SES. However, if viewed from the side, the full extent of the SES iceberg stretches far below the surface. The subsurface dimensions of SES dynamics include hidden system feedbacks, aspects of system design, and the goals and paradigms that underpin the underlying intents that shape SES dynamics.

the past decade. To understand what is meant by this, it is useful to conceptualize SES through the metaphor of an iceberg (Figure 1). If viewed from above, only the tip of the iceberg is visible, and this represents key parameters, variables and feedbacks of an SES. However, if viewed from the side, the full extent of the SES iceberg stretches far below the surface. The subsurface dimensions of SES dynamics include hidden system feedbacks, aspects of system design, and the goals and paradigms that underpin the underlying intents that shape SES dynamics.

The iceberg metaphor has strong parallels with the leverage points framework, (Meadows 1999). This framework presents a hierarchy of leverage points (or interventions) in complex systems, that range from those that are shallow (easy to carry out, but limited in their potential to bring about transformative change) to those that are deep (difficult to carry out, but have great potential to bring about transformative change). Recently, the original Meadows framework was revisited, and the leverage points were reconceptualized into four 'realms of leverage' (Abson et al. 2017). These realms are (from shallow to deep) focus on: parameters (mechanistic characteristics typically targeted by policymakers, such as the number of hectares of forest preserved), feedbacks (interactions between elements of a system that drive internal dynamics, such as interactions between people and the natural landscape), design (social structure and institutions that manage feedbacks and parameters), and intent (values and worldviews of actors in the system). For example, SES research in Southern Transylvania, Romania has provided insights on how local actors leverage change to foster sustainability, through different relations and networks across these four realms (Lam et al. 2021). At the global-level, the leverage points framework was recently used in the IPBES Global Assessment report, which applied a social – ecological systems lens to identify eight leverage points (priority points for intervention) and five levers of change (strategic actions and priority interventions), which appear to be key to societal transformation (Brondizio et al. 2019; Chan et al. 2020).

Although SES research has a long tradition in at least considering the design and intent of a system (Folke 2006), the focus on deeper realms of leverage has recently moved from the margins to the center of SES research. In the following sections we highlight some of the ways by which the growth of place-based SES research over the past decade, fostered by networks such as PECS, has contributed to these developments.

Contribution 1: place-based SES research sheds light on transformational change

Transformational change implies a fundamental shift of a SES from one regime and its associated development pathways to another (Westley et al. 2011). This includes alterations in the way that authority and resources are structured and flow through systems; the norms, values, and beliefs that underpin those structures and processes; the functions and dynamics

of ecosystems; and the ways that all of these are connected to one another across multiple scales (Moore et al. 2014). Sustainability transformations can therefore be conceptualized as shifts from regimes associated with unsustainable pathways of development to alternative regimes in which development pathways are sustainable (Clark and Harley 2020). Place-based SES research has been instrumental in highlighting the linkages between sustainability transformations and deeper realms of leverage. For example, research from New Zealand showed how sustainability transformations were triggered by a strong sense of place (deep attachment and commitment to a place or region) among residents, and were driven by local communities rather than imposed by an external authority (Chapin et al. 2012). Recent work in Papua New Guinea provides compelling evidence that the underlying structure of social networks can influence transformative actions in response to climate change. Social networks determine who accesses information, resources, and support. People influence each other through social networks, and plan for uncertainties and change through their social relationships. In Papua New Guinea, households that were socially connected to other households who were taking transformative action (e.g. switching livelihoods), were more likely to do the same (Barnes et al. 2020).

Achieving transformations to sustainability also requires identifying and addressing barriers to change, such as inequality, power asymmetries, or environmental degradation (Moore et al. 2014; Leach et al. 2018). Place-based SES research has helped to shed light on how barriers for sustainability transformations are linked to deeper leverage realms. For example, recent research exploring the narratives of stakeholders associated with the wetland of Xochimilco in Mexico City, shows that barriers to sustainability transformations can be the cognitive or emotional capacities of residents to accommodate landscape change while still enabling the values they have come to associate with the landscape (Eakin et al. 2019). Scenario planning with communities in a traditional cultural landscape in Transylvania, Central Romania, uncovered the hidden interactions between external barriers (e.g. lack of government support) and internal barriers (e.g. stakeholder worldviews, lack of community cohesion) to taking transformative action towards sustainability (Nieto-Romero et al. 2016).

Studies of how transformational change occurs in SES have shown that local processes and initiatives can shape regional and global dynamics, through different processes such as aggregation, contagion, and social learning (Carpenter et al. 2006; Grin et al. 2010; Bennett et al. 2021). Growing evidence from place-based research suggests that large (macro-scale) changes emerge from substantial periods of experimentation at the micro-level that lead to the formation of initiatives, experiments and innovations with transformative potential (Bennett et al. 2016). These transformative entities represent a diversity of worldviews and values, which are currently not dominant or prominent at the global scale. An emerging opportunity context (such as a crisis, or an anticipated crisis) can destabilize the existing regime and allow these initiatives, experiments and innovations to amplify their impact and to start becoming institutionalized at higher levels (Folke et al. 2005; Pereira et al. 2017a; Herrfahrdt-Pähle et al. 2020; Lam et al. 2020b). Place-based SES research can engage with such local 'seeds' to create transformative spaces that inspire and empower people to act toward positive sustainability pathways (Pereira et al. 2017b; Sellberg et al. 2020).

Contribution 2: place-based SES research reveals the social dynamics shaping SES

Place-based research on social-ecological systems reveals the extent to which local human-nature interactions are often determined by social dynamics, such as norms, values technology, and social practices (Stone-Jovicich et al. 2018). Revealing the social dynamics (which connect to deeper realms of leverage) is especially evident in place-based SES research focusing on ecosystem services and nature's contributions to people (Pascual et al. 2014; Díaz et al. 2018). Approaches such as the concept of 'ecosystem service elasticity' are providing analytical and operational tools to unearth how different people access ecosystem services, and how this access is determined by dimensions of justice and power relations (Felipe-Lucia et al. 2015; Daw et al. 2016). For example, SES research conducted in southeastern Oklahoma revealed how regional conflict over access to water resources by Native American Indians (i.e. Choctaw Nation) was caused by unequal historical power relationships (Castro et al. 2016; Burch et al. 2020). In an analysis of ten SES case studies from the Global South, Zafra-Calvo et al. (2020) found that power asymmetries can severely hinder equitable and sustainable outcomes. This negative effect of power asymmetries and inequities can be lessened by considering five points which are key to much of SES research: eliciting participatory values, following a clear action-oriented purpose, providing space for marginalized actors, reconciling different cognitive models of human-nature relations, and fostering open communication and collaboration among actors. Studies from southern Africa highlight the legacies of unjust and racially discriminatory land ownership and governance systems as well as the role of factors such as property rights, skills, and

access to financial and technical resources in determining access to ecosystem services (Biggs et al *in press*). Understanding how different actors exercise power through their discourses is one of the critical ways how place-based research has explored enabling-conditions for sustainability transitions that are linked to local realities (Gelcich et al. 2005; Martinez-Harms et al. 2018).

Power relationships at local scales are also dictated by global dynamics (Downing et al. 2021). For example, in the Nacimiento watershed in southern Spain, the 'cross-scale influence-dependence framework' developed by Martín-López et al. (2019) revealed how the power exerted through legislation by government policy-makers at the regional and European levels has led to the technological upgrading of ancient irrigation channels. This, in turn, had a negative impact on the supply of essential ecosystem services for local farmers, such as water regulation and erosion control. Inequities and power asymmetries also influence how different individuals and groups value nature. For example, some social actors get more power in the decision-making because their interests are represented by the valuation output, while others remain unheard. Striking examples of this are fracking megaprojects, where the destructive pursuit of short-term economic profit for the few, comes at the cost of the local economy, quality of life and the diversity of values of nature for the many. The decision power of affected local communities is extremely low, resulting in protest, conflict and despair (Phelan and Jacobs 2016).

Contribution 3: place-based SES research brings together diverse types of knowledge

Place-based SES research typically brings together diverse types of knowledge to address real, practical issues around sustainability, through knowledge co-production. Knowledge co-production is an iterative and collaborative process involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future (Norström et al. 2020). Importantly, these processes engage with deeper realms of leverage and can be agents of sustainability transformations (Moser 2016; Turnhout et al. 2020). Successful knowledge co-production is context-based, pluralistic, goal-oriented and iterative (Norström et al. 2020). Place-based SES research and its application is highly aligned with these principles, and therefore well-positioned to produce high-quality knowledge co-production (Balvanera et al. 2017c). For example, place-based SES research addresses the unique features of specific landscapes, seascapes or transitional zones (Balvanera et al. 2017b), with a strong focus on the socio-economic, political, and biophysical elements that distinguish a place from other areas. It is typically adapted to the local context, which also means that the needs, interests and beliefs of different social groups who are affected by a given challenge are taken into account. However, the understanding of processes, mechanisms, levers and barriers affecting place-based initiatives in one context generates knowledge applicable to other cases. Place-based SES research often involves long-term and frequent engagements with relevant actors (Balvanera et al. 2017c). This facilitates the development of trustful relationships among actors, and the engagement of a plurality of perspectives, knowledge, and expertise. Increasingly, this also includes consideration of indigenous and local knowledge (Tengö et al. 2017; Lam et al. 2020a; Hill et al. 2020).

Place-based SES research has also increased awareness of the importance of bringing together different knowledge systems. For example, citizen science has proliferated in the last decade, becoming an important research tool in place-based SES research, and a critical form of public engagement that can connect people more closely with a place, and encourage people to participate more fully in being stewards of those places (Crain et al. 2014; Loos et al. 2015; Toomey et al. 2020). Similarly, a growing body of literature is highlighting the utility of traditional and local experiential knowledge in documenting species abundance and trends (Beaudreau and Levin 2014; Sáenz-Arroyo and Revollo-Fernández 2016; Lee et al. 2019). Recent work on Canada's northern coastal SES synthesized multiple types of knowledge sources (zooarchaeological, historical, traditional, and western science) to document changes in relative abundance of key species from the Holocene to present. This generated more accurate historical density estimates than those derived from western science alone (Lee et al. 2019). Another strand of research is focusing on unearthing the negative consequences of applying narrow approaches to valuing nature when trying to foster sustainability and justice (Jacobs et al. 2016, 2018; Zafra-Calvo et al. 2020; Martín-López 2021). The choice of narrow valuation approaches has led to the exclusion of certain social actors, and their needs, interests, preferences and worldviews in relation to nature (Martín-López 2021). The need for plural valuation has not only gained traction in the scientific literature, but also within science-policy platforms. For example, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has developed a broad plural valuation framework, which aims at bridging worldviews and values held by diverse societal actors, from financial enterprises to indigenous and local communities (Pascual et al. 2017; Tengö et al. 2017; Díaz et al. 2018).

Place-based SES research also draws on a diversity of methodologies from many different disciplines. A recent systematic review identified 311 methods grouped into 27 categories of methods that are commonly used in place-based SES research (de Vos et al. 2019). Many of the most common methods (such as interviews, futures analysis, participatory data collection, livelihood and vulnerability analysis) facilitate a focus on deeper SES dynamics. For example, analysis of futures (e.g. participatory and normative scenarios) is a powerful and rapidly evolving set of tools that allow to explore, identify and analyze alternative futures, for reaching societal and political sustainability goals (Oteros-Rozas et al. 2015; Kanter et al. 2016; Merrie et al. 2018). This family of methods can help to unearth innovations and visions for the future, providing the basis for creating momentum, involving self-organization around new ideas, the creation and mobilization of networks of support, and experimentation in protected niches. In a similar vein, participatory research approaches foster learning among participants and can underpin processes of individual or collective behavioral change (Kansanga et al. 2021; Below et al. 2021). Recent years have also seen the emergence of new, integrative modeling approaches and analytic frameworks that are agnostic to disciplinary boundaries, that focus on uncovering SES design and intent (Martín-López et al. 2019; Thiault et al. 2020). These developments have fostered a new generation of sustainability researchers who are comfortable in using multiple conceptual frames and methodological approaches to solve real-world problems, open to accepting new approaches, and epistemologically agile in adopting multiple methods in their own work (Biggs et al. 2021).

Contribution 4: place-based SES research encourages reflexive researchers

Place-based SES research is often long-term, involving a deep engagement with specific places and their associated epistemologies (Robinson et al. 2016). Consequently, the researchers involved allocate a substantial time to iterative cycles of learning and reflection across all stages of the research process (Cockburn 2018; Sellberg 2018; Lam 2021). This mode of SES research has been likened to a 'reflexive research journey' and involves reflecting on the underlying assumptions and values of the actors involved (including the researchers themselves), and identifying positions of power and sources of inclusivity and justice. The integration of divergent disciplines, perspectives and knowledge systems can be intimidating and even lead to confrontation (Ives et al. 2020). Practicing place-based research fosters the ability to remain humble, open-minded, open to learning, open to new ways of doing things and open to collaborations that include new types of disciplinary as well as non-academic knowledge. One example of how to adopt such new, deeply reflexive approaches has been proposed by a team of scientists in the context of transgressive, decolonial and post-normal research: they use seven Tarot 'characters' to challenge dominant forms of knowledge production and to enhance collective and personal reflexivity (Temper et al. 2019). Emerging novel questions and perspectives force researchers to revisit what type of science to do and how (Sellberg et al. 2021). A broad range of skills are developed (or honed) in this context, such as facilitation, conflict resolution and a focus on self-awareness and self-care. Ultimately this results in deeper, reflexive scientists.

This reflexive process often leads to the development of ameliorative strategies to sustainability challenges that go beyond shallow leverage points (i.e. small tweaks to existing institutions) (Fischer et al. 2012; Mukhovi et al. 2020). Clearly, a place-based SES research process is also a process of change, with researchers moving from curiosity-driven system observers to increasingly engaged – though of course still curious – scientists and participants. Sometimes, researchers even become agents of change (e.g. transformative space-makers), actively engaged in not only understanding systems, but also in facilitating action for change (Marshall et al. 2018; Pereira et al. 2019). Scientists can reflect on their power, to apply it consciously and in a transparent, and rethink the traditional posture of 'the scientist' in face of the current biodiversity crisis (Jacobs et al. 2020). A number of approaches, such as decision trees, are emerging to help scientists identify their role and the purpose of the knowledge they produce (Crouzat et al. 2018). Furthermore, by co-designing and co-producing research with non-academic actors, researchers can make SES research legitimate, credible and relevant (Cash et al. 2003; Chambers et al. 2021). This could contribute to countering the current trend of science being increasingly misunderstood, mistrusted, and even feared in political and popular discourse. It does, however, require careful reflection on the – sometimes highly divergent – interests of and power relations among the various non-academic actors involved (Brandt et al. 2018).

Innovative art-based methodological tools have been recently used in place-based SES research to encourage reflexivity in scientists as well as non-academic actors For example, Muhr (2020) has used tools emerging from the scenic arts (Boal 2002) to identify social dilemmas and power relations, and foster collective and individual reflections among participants of a research on human-nature connectedness. The arts-based methods enabled the unravelling of new nuances of emotional human-nature connectedness (that

couldn't have been captured through other methods such as interviews or questionnaires), but they also led to the co-creation of new knowledge on participants' personal connections to nature (Muhr 2020). Indeed, art is increasingly being acknowledged as a natural part of social-ecological collaborations and a powerful tool to ensure creative and reflexive thinking (Scheffer et al. 2015). For example, the South American Institute for Resilience and Sustainability Studies (SARAS Institute) in Uruguay was founded with the explicit intent of using art and science together to think about sustainability (Scheffer and Mazzeo 2019).

Outlook

Place-based SES research has enabled SES science to deepen in multiple ways, and has substantially contributed to an improved understanding of the broad economic, social, and cultural dimensions required to safeguard the resilience of the biosphere. In the coming decade, we envision that PECS (and place-based SES research in general) will continue to foster biosphere stewardship – the active shaping of social-ecological change that reduces vulnerability to expected changes while transforming from undesirable pathways of development when opportunities emerge. It is a learning-based process with a clear direction and vision, engaging people to collaborate and innovate across levels and scales as integral parts of the systems they govern. Living with complexity and change requires adaptive approaches to management and decision making that can cope with high uncertainty (Polasky et al. 2011). These approaches are essential for biosphere stewardship, aligned with the place-based focus of PECS, and are therefore a high research priority for the future.

Due to its embedded and contextual nature, place-based SES research offers conducive conditions for research to engage with the transformative political movements of our time, such as those that seek to address race relations, patriarchy and colonialism. The next ten years will also offer the opportunity to delve more deeply into what are increasingly less marginalized academic arguments, like how to rewire our economic system as a fundamental requirement for sustainability (Hickel 2020).

Challenges exist, especially related to the transferability of place-based research, and these need to be addressed. For example, the co-production of knowledge inherent to place-based SES research can limit the transferability of its outcomes, because the credibility of indigenous and local knowledge by national or international actors is still an issue in some arenas. Communication barriers (different languages and dialects), and differences in world views, perceptions, or needs can also hinder transferability across sites. Upscaling place-based research also faces several methodological challenges. The development of better ways to collect data that can facilitate comparison between different local place-based case studies remains an important challenge for PECS, and the broader SES research community (Cumming et al. 2020). A more practical challenge is to develop mechanisms, such as insurance funds and legislative support, that provide communities with security while they participate in local experimentation to uncover potentially transformative solutions (Cumming et al. 2013). In addition, the development and utilization of networks that encourage the diffusion of effective solutions between people and places will be critical if regional impacts are to be achieved (Mascia and Mills 2018). Comparative analyses of the patterns and mechanisms that make local interventions a successful endeavor may synergistically guide action at regional and global scales (Epstein et al. 2021). Balvanera et al. (2017a) highlight four key emerging pathways by which place-based research can inform global sustainability, including new institutional research settings, a global community of practice and importantly long-term networks of place-based research such as PECS. Through this, place-based SES of the past and the upcoming decade may provide evidence to safely govern the world and its inhabitants through the Anthropocene.

Note

1. https://futureearth.org/.

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