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Synthesis, part of a Special Feature on Learning from Doing: Closing Knowledge Gaps in Integrated Landscape Research

Landscape transition science: relational praxis for continuous learning

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ABSTRACT. We introduce landscape transition science as a new field that builds on integrated landscape approaches (ILAs) to address sustainability and justice through deliberative, place-based boundary work. Here, we critically examine ILAs, and identify key issues that limit the efficacy of ILAs in achieving sustainability and justice transformations. These issues include contestation, dominance of normative and western systems, and lack of critical reflexivity. We outline landscape transition science as an advancement to ILAs by emphasizing key elements of pluralism, relational praxis, and reflexive learning. Across each of these elements, landscape transition science encourages dialog between critically interpretive sciences and normative sciences to engage more explicitly with power, politics, values, and justice. In focusing on relational praxis for continuous learning in landscape transition science, we provoke some questioning about how to enable meaningful and just landscape transitions that hold complexity and change. We conclude with ways forward for developing institutional and individual capabilities for landscape transition science, emphasizing humility, patience, and relationality in improving the currently fraught science–policy–society–nature relationships. Landscape transition science responds to global calls for new transformative research and advancing concepts and practices that can inform ILAs seeking just transformations in landscapes.

Key Words: *integrated landscape approaches, learning, relationality, relational praxis, sustainability transitions, transformations*

INTRODUCTION

We argue for a new kind of science that builds from advances in integrated landscape approaches (ILAs). We call this new science "landscape transition science"; it prioritizes the capabilities of institutions to learn by focusing on relational aspects of concepts and practices (combined as relational praxis, as described in Table 1) pursued in the sustainability sciences that underpin ILAs. We articulate how this science would fill gaps and rectify problems that have been identified in contemporary theories and discourses that call for transformational change for sustainability and justice (Scoones et al. 2020, Avelino et al. 2024). Landscape transition science, through its emphasis on pluralism, relational praxis, and reflexivity (described in Table 1), hones the concept and application of boundary work through the identification and reconciliation of epistemological and ontological differences for continuous learning and adaptation (Caniglia et al. 2021, Zurba 2022, West et al. 2024). Through these key elements, and grounding boundary work in landscapes, we consider how landscape transition science helps to improve relationships among science, policy, society, and nature (henceforth referred to as the science–policy–society–nature interface). Considering these as an interface acknowledges the effects of each domain on the other, the gaps and interlinkages of the relationships, and their systemic qualities. This fills a key gap in confronting fundamental issues of power and politics, justice, complexity, capabilities, and deliberative foresight. As such, we think landscape transition science should provide a meaningful and legitimate way forward to audiences interested in addressing the complex and interlinked challenges facing people and nature, and in pursuing change that better integrates sustainability and justice.

Our motivation for writing this paper is to overcome shortcomings in how science has integrated the lessons from different sustainability and justice-oriented fields, to better enable their stated goals for transformations (Stirling et al. 2023, Turnhout 2024). The transformational change agenda has become a dominant framework for sustainability issues across many different contexts: urban development (Li et al. 2024), food systems (Moallemi et al. 2024), energy transition and climate mitigation (Moore et al. 2021), climate adaptation trajectories (Garcia and Tschakert 2022), economies and governance structures (de Castro et al. 2025), biodiversity conservation (Pascual et al. 2023*a*), and co-production and learning (Chambers et al. 2022).

Recent conceptual and practical advances in transformations have focused on how to accelerate transitions and leverage efforts to achieve just transformational change (Dorninger et al. 2020, Avelino et al. 2024, Moallemi et al. 2025). Transition and transformation are relational and heuristic concepts (see Table 1). The threshold for transformational change varies by context and has multiple interpretations (Feola 2015) that we understand to exist on a spectrum, rather than a binary between incremental adjustments and to more fundamental shifts and deliberate transformations (Kates et al. 2012, O'Brien 2012, Larson et al. 2021).

Translating these insights into landscape-scale approaches and initiatives has received less attention, with studies finding landscape-oriented partnerships fall short of integrative, reflexive, and anticipatory approaches needed to bring about systemic change (de Koning et al. 2023). Shortcomings in the

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Table 1. Concepts underpinning landscape transition science.

Domain	Concept	Description	Key sources
Pluralism and justice	Pluralism	Recognizing, appreciating, and honoring diversity and contestation, in the context of values, knowledge systems, world views, and perspectives	Kenter 2016, Caniglia et al. 2021, Turnhout 2024
	Values and justice	Multiple dimensions of justice; confronting power and inequalities; recognizing epistemic and ontological differences, and diverse human–nature relationships	Forsyth et al. 2021, Wijsman and Berbés-Blázquez 2022, Avelino et al. 2024
Science–policy–practice interface	Relational praxis	Understanding and engaging with complex phenomena as constitutive processes and relations, through an ethic of care, sensitive to comparative notions of justice, and recognition of Indigenous epistemologies	West et al. 2020, Gould et al. 2023, Böhme et al. 2024
	Reflexive learning	Critically examining thoughts, values, assumptions, beliefs as in multi-directional and reciprocal learning	Lotz-Sisitka et al. 2015, Popa et al. 2015
	Boundary work	To create, maintain, break down, and manage the interfaces between different perspectives or forms (stakeholders, disciplines, knowledge systems, cultures)	MacMynowski 2007, Clark et al. 2011, Zurba 2022
Complexity and change	Landscape	Relational concept that integrates environmental and social dynamics in a spatially bound area, often associated with certain values, meanings, and sense of place	Sayer et al. 2013, Opdam et al. 2015, Ros-Tonen and Willemen 2021, Langston et al. 2024
	Transition	Fundamental shifts in socio-technical systems, characterized as long-term, involving multiple actors and elements, with normative directionality	Markard et al. 2012, Köhler et al. 2019, Geels et al. 2023
	Transformation	Large-scale changes in structural, functional, relational, and cognitive aspects of social–technical–ecological systems	Patterson et al. 2017, Hölscher et al. 2018, Scoones et al. 2020

performance of ILAs are illustrative of this gap (Estrada-Carmona et al. 2024). Calls to embrace relationality across the broader sustainability sciences seek to respond to these shortcomings, but there remains a gap in the implications for situating action research at the science–policy–society–nature interface (West et al. 2020, Avelino et al. 2024).

Throughout this paper, landscapes and boundary work remain the grounding concepts for understanding and dealing with systems complexity (Langston et al. 2024). We begin this paper articulating a history of evolution of ILAs and discuss lessons relevant to allied sustainability sciences. We aim to apply these lessons to an emergent field of landscape transition science. We characterize the ongoing gaps in ILAs that landscape transition science could help to address. We unpack the approaches and relationships that ILAs (and related sciences) might prioritize to better contribute to justice and sustainability transformations by filling these gaps. From these insights, we derive key elements that we define as central to landscape transition science. Building from ILAs, these key elements of landscape transition science, include (1) engaging with pluralism, (2) advancing relational praxis, and (3) learning for deliberate transformations. We describe how these elements fit together to contribute to a meaningful and operational transformational change agenda. Our aim is to provide guidance to support institutional capability that is fit for achieving transformations and offer the elements of landscape transition science to advance this cause.

Positionality statement

Our conceptualization of landscape transition science emerges from diverse and interconnected discussions amongst a group of researchers addressing environmental, resource, conservation, and development issues in Indonesia and Australia. We represent diverse disciplinary backgrounds, gender identities, religions, ethnicities, cultural contexts, and career stages. We bring expertise in anthropology, agronomy, conservation science, environmental economics, forestry, human geography, political ecology, science and technology studies, systems science, and sustainability science. We have all engaged with the science–policy–society–nature interface through our conceptual and practical work as academics and researchers at universities, government agencies, and public research institutions.

Our co-authorship began with the recognition that justice and sustainability transformations are urgently needed but that current understandings, latent tensions between different approaches, and dominant scientific norms, funding, and institutional structures, are not conducive to navigating and influencing changes. Through a series of workshops and discussion,[1] we reflected on our own conceptual and empirical work about and within landscapes. In these discussions, we agreed that people, in relationship with their "places," deserve meaningful approaches that build and enable learning-oriented partnerships that confront power and politics with the purpose of contributing to improved justice and sustainability outcomes. We all have exposure to ILAs in our work, some as leaders in the publishing realms of ILAs, and others as critical observers in associated publishing fields. Discussions started with reflecting upon how ILAs fall short on delivering on these outcomes and then began to consider what needs to change in the science–policy–society–nature interface to achieve the intended aims of ILAs. The co-authors agreed to contribute to developing concepts that might enrich the conceptualization and practice of ILAs in the larger fabric of sustainability sciences, and in advances in our respective fields. The early stage of drafting this manuscript led to recognition of the importance of pluralism, relational praxis, reflexive learning, and boundary work (Table 1). We explore how these come together and advance the ILA agenda and underpin what we think is a new landscape transition science.

The following sections describe the conceptual grounding for landscape transition science that emerged from our discussions. As co-authors, we are positing that landscape transition science is critical to achieving just and sustainable transformational change. We discuss how progressing relational praxis will help achieve (1) a careful consideration and management of multiple and contested (plural) values and (2) strengthened cross-boundary learning for improving science–policy–society–nature relationships. Boundary work is central to this science, and relational praxis in landscapes hones place-based boundary work, calling for individual and systemic capabilities more conducive to learning and well-being. The major difference between landscape transition science and previously defined landscape sustainability

science (Wu 2013) is its focus on "relationality" (West et al. 2020) and its spanning of critically interpretive and normative sciences. Landscape transition science focuses on relationships between more critically interpretive sciences (such as political ecology and sociology) and more normative sciences (such as behavioral and natural resource economics). Rather than emphasizing specific methods and frameworks, we aim to provoke questioning and learning about what it means for science to be involved with landscape transitions to achieve justice and sustainability transformations.

MUDDLING THROUGH: THE GROWTH OF INTEGRATED LANDSCAPE APPROACHES

An intended strategy of ILAs is to reconcile trade-offs between production and conservation in land-use decisions by situating landscape as the conceptual intervention and entry point (Sayer et al. 2013). Integrated landscape approaches are generally defined as long-term collaborative engagements to identify, reconcile, and ideally satisfy multiple and competing interests in "contested places" (Sayer et al. 2017). Landscape thinking has grown from coalitions of practitioners, scientists, and boundary organizations, bridging the gap between international discourses and local socio-cultural realities, to achieve healthier science–practice–policy relationships (Arts et al. 2017, Byron and Sayer 2020). Practitioners and scientists have considered landscapes and landscape approaches useful for pursuing a transformative, just, and sustainable research agenda for nature and people (Sayer 2009, Larson et al. 2021).

Prior to a keystone publication in 2013, known as the "ten principles paper," outlining ILAs (Sayer et al. 2013), much of landscape science focused on biophysics of landscape ecology, conservation biology, and relevant linkages of how humans could better steward nature (Opdam et al. 2018, Margules and Pressey 2000). The ten principles paper advanced the scope for how landscape science could provide a better fit for achieving sustainable development, by moving beyond top-down, disciplinary, and operational boundaries of ecology or conservation sciences into the "messy human realms" of interconnected decision making involving multiple actors, values, and knowledge systems (Sayer et al. 2013, Waeber et al. 2023). The principles and ethos of ILAs have since been reified through globally influential institutions such as the Global Landscapes Forum, UN conventions on climate and biodiversity, the Consultative Group on International Agricultural Research (CGIAR) and affiliates, World Heritage, and numerous agricultural and land-use research organizations. They have provided educational guidance and operational and tactical recommendations aiming to reconcile wicked problems of sustainable development. Integrated landscape approaches also have gained traction in subnational fora, helping to mobilize local values, practices, and knowledge. We think the growth of these approaches has been a welcome step away from techno-managerial approaches that are often predominant in normative science institutions (Swyngedouw 2022).

Integrated landscape approaches have been described as process oriented and more akin to "muddling through" than adhering to grand designs or prescriptive processes (Sayer et al. 2014, Arts et al. 2017). A reason for this has been continually responding to the lessons that prescriptive "one size fits all" solutions fail. As such, ILAs deal in responding to context specificity. Despite some scalar, conceptual, and operational "fuzziness" (Langston et al. 2024), ILAs have gained traction as entry points for actors pursuing an integrated agenda for sustainable development (Sayer et al. 2013, Reed et al. 2016). This conceptual and practical flexibility contributes to their strength. Although some criticize their lack of theoretical or practical clarity and rigor (Erbaugh and Agrawal 2017), ILA uptake and use have proliferated through global conventions and the operational strategies of national and international conservation agencies, private sector, and civil society enterprises (Riggs et al. 2021, Reed et al. 2023). We support the notion that ILAs represent an ethos to "guide land management toward an integration of policy and practice that ensures sustainable, equitable, and balanced land use; strengthens climate change mitigation and adaptation; and provides adaptive and inclusive management pathways for a specific area" (Erbaugh and Agrawal 2017).

Initially, ILAs paid insufficient attention to the socio-political contested nature of decisions affecting places (Reed et al. 2020, Riggs et al. 2021). Practitioners recognized this and began to situate "governance" at the forefront of their mental models and theories of change for confronting sustainable development concerns in landscapes (Langston et al. 2019*a*). Integrated landscape approaches are now seen by many as an explicit way to deal with contextualized governance issues, which are seen as a main hindrance to sustainability (Ros-Tonen et al. 2024). They can now be characterized as negotiable forms of landscape governance intended to integrate multiple domains of human and nature interactions (Ros-Tonen et al. 2018).

Integrated landscape approaches orientation toward the United Nations Sustainable Development Goals (UN SDGs), and their appreciation for local complexity, positions them well for boundary work aimed at accelerating and fulfilling transformative global agendas in ways that are locally just (Malekpour et al. 2024). Because of this, ILAs show potential to address ongoing calls for transformative "nexus" science agendas (McElwee et al. 2025), which ask for integrated, inclusive, experimental, and boundary-spanning methodologies (Braun 2015*a*). Integrated landscape approaches have emerged as a methodological and operational way forward (Mattocks 2021). However, we argue that ILAs have not yet met this potential. Gaps remain in dealing with the socio-political contested space of relationships and learning that drives decision making and implementation. As such, ILAs could progress by more purposefully spanning the critically interpretive fields and the more normative sustainability science fields. This would contribute to addressing an underdeveloped and critical dimension of ILA boundary work.

LIMITATIONS OF INTEGRATED LANDSCAPE APPROACHES: ADDRESSING FRAUGHT RELATIONSHIPS AND BOUNDARIES

To examine shortcomings in ILAs, we consider the so-called "relational turn" in sustainability science, as it relates to advancements in ILAs (West et al. 2020). Relationality encompasses "attempts to understand complex phenomena in terms of constitutive processes and relations and recognizes the intricate inter-connectedness of humans and the more-than-human world, as well as the associated nonlinear dynamics, uncertainty, and the emergence of change" (Böhme et al. 2024). Relational thinking distinguishes itself from atomistic and

substantialist approaches and embraces a diversity of relational research, praxis, ontologies, and epistemologies (West et al. 2020). Integrated landscape approaches are inherently relational to an extent—they are multi-sectoral, multi-scalar, and organize around social-ecological systems (Langston et al. 2024). Boundary work, central to ILAs, explicitly aims to constructively address these relationships (Arts et al. 2017). But there remain knowledge gaps in the critical understandings of "science" and the various science–policy–society–nature relationships, which are key to, yet under-developed in, ILAs. We broadly characterize these gaps into three themes: conceptual and material contestation, dominance of normative and western systems, and lack of critical reflexivity (Fig. 1), which are described below.

Conceptual and material contestation

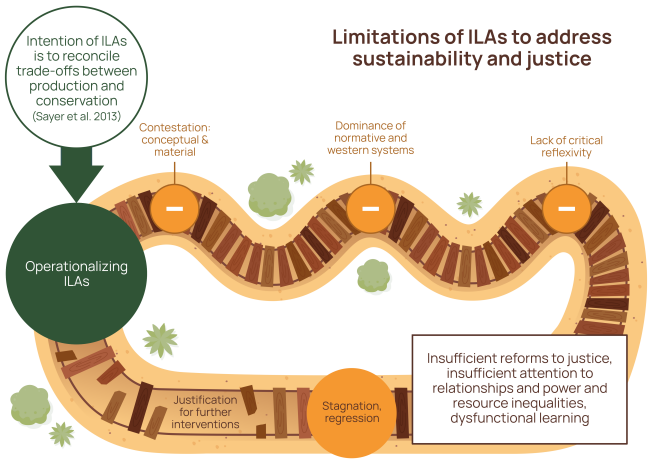
Integrated landscape approaches approach landscapes as relational places, where people and nature interact, and where different and competing visions, technologies, and drivers of change can be interrogated and made visible for navigating trade-offs. But the concept, meaning, and application of "landscape" remain contested, creating fundamental challenges for ILAs (Meinig 1979, Ros-Tonen et al. 2024). Dealing with this contestation requires capabilities that center on relationships and boundaries that are fraught. Additionally, landscapes are subjectively framed by people's perceptions of value, i.e., the issues that matter to people in everyday practices and spatio-temporally across jurisdictional, ecological, and generational boundaries (Langston et al. 2024). This prompts questions as to "what change" is desired, "by whom?," and "for whom?," and what is the role of "science" for ILAs in dealing with these questions of change (Beunen and Opdam 2011, Boedhihartono and Sayer 2012, Riggs et al. 2023, Ligtermoet et al. 2025)? These are difficult and important social and ethical questions for transitions and transformations that ILAs have not sufficiently grappled with (Bieling et al. 2020, de Koning et al. 2023).

Dominance of normative and western systems

Dominance of normative and Western knowledge systems are evident in ILA goal-setting and knowledge-production economies. Landscape sustainability science (Wu 2013) has advanced sustainability as a normative goal of measuring and accounting without delving into much of the socio-political dimensions of change. But as landscapes are inherently dynamic, the spatial scale in which landscapes are understood is socially and politically constituted, in flux, and responding to the range of actors' needs (Reed et al. 2016). Navigating these subjectivities requires shared capabilities to reflexively engage with diverse ideas and inherent bricolage (the improvised process of adapting formal and informal institutional arrangements to address locally contextualized challenges) (Cleaver 2017, van Oosten et al. 2021). We think that, at present, ILAs risk over-influence from normative sustainability institutions (i.e., the target-based and managerial-based agencies like the UNSDGs, IPBES, FAO), rather than drawing on critically interpretive approaches that deepen learning for navigating complexity. A re-balance that ensures continual learning among people and across various boundaries for adapting to inevitable uncertainties and constant change is desirable.

Integrated landscape approaches encourage change by shifting from the provision of tools to support decision makers and resource users toward engaging directly with locally specific and

Fig. 1. As people implement and experience integrated landscape approaches, successes are stymied by three related limitations of our collective capabilities, (1) conceptual and material contestation, (2) dominance of normative and western systems, (3) lack of critical reflexivity, all of which hamper learning and actions for sustainability and justice.



endogenous forms of governance and political, legal, social, economic, and ecological dimensions (Beunen and Opdam 2011, Opdam 2018). But as the question lingers, what "happens to the science" in this process (Beunen and Opdam 2011, Opdam 2018)? Integrated landscape approaches still tend to operate in conventional scientific approaches that privilege "Western" scientific knowledge systems, hampering their effectiveness in spanning boundaries. The dominance of Western science systems (those based in reductionist notions of separability) hinders responses to calls to restore damaged relationships and correct persistent and relational injustices (Doyon et al. 2021, Gould et al. 2023). Indigenous ontologies and place relationships have been damaged by colonial and neoliberal paradigms that minimize relational ways of knowing and being, continuing to separate local and "Western" scientific knowledge and learning systems (Davis and Todd 2017). Science is a heavy word with a long etymological history, originally evolving from the Latin "knowing and experience" to English as "collective knowledge." These origins characterize a more inclusive and useful application of the word science: as knowledge–experience learning interactions entwined in societal notions of progress (Langston et al. 2019*b*).

Currently, globally, the neoliberal economy dominated by consultants benefits from an "information as a commodity" arrangement, but in ways that continue to degrade relationality (Mazzucato and Collington 2023). The consulting knowledge economy drives science–society–policy relationships toward modalities that further dislocate capabilities from local landscapes (Langston et al. 2019*b*, Turnhout and Lahsen 2022, Mazzucato and Collington 2023). Global sustainability solutions produced through models and technologies (big data, remote sensing, AI, and other computational soft- and hardware) reinforce siloed, asymmetrical, and fragmented systems, which are typically abstracted from place and blind to relational justice (Bull et al. 2018, Fremaux and Barry 2019). Calls to disrupt and decolonize these systems force a re-examination of dominant

values and assumptions in ILAs, and how science spans (trans) disciplinary and diverse societal boundaries, to recognize and embed more just forms of knowledge production into landscapes (Mancilla García et al. 2020).

Lack of critical reflexivity

Critically and reflexively engaging with diverse values, knowledge claims, and political–economic structures helps to inform what changes and change processes (what we mean by transitions) are necessary. We acknowledge that progress has been made in ILAs toward recognizing and legitimizing the transdisciplinary decolonized methodologies that (re)center the lives of the collective and disempowered (Ramcilovic-Suominen et al. 2024). But ILAs could better enable transformations by uncovering the fraught relationships that drive injustice and hamper sustainability. To do this involves dealing with plural knowledges and confronting the politically contested space of "science" (Turnhout and Lahsen 2022) through careful and reflexive attention to positionality: how people (re)position themselves, their work, their mindsets and behaviors, to ground sustainability transition sciences for meaningful transformations (Waeber et al. 2021, Böhme et al. 2024). This involves advancing reflexivity: prioritizing a learning-oriented and deliberative process for navigating sustainability in ways that recognize justice and sustainability in landscape contexts (Ligtermoet et al. 2025).

Globally, the Intergovernmental Panel for Biodiversity and Ecosystem Services (IPBES) has articulated and pursued values-centric approaches to framing just sustainability transformations in their attempts to close science–policy gaps for nature and people (Pascual et al. 2023*b*, van Noordwijk et al. 2023, Willemen et al. 2023). Latest Intergovernmental Panel for Climate Change (IPCC) reports indicate the need for systemic changes in how human decisions advance adaptation and mitigation as the world crosses critical temperature thresholds (IPCC 2023). Achieving these transformations requires a more generous, inclusive conception and application of science (Turnhout 2024), which centers people–place–practice relationships (Langston et al. 2024, West et al. 2024). These arguments form the foundations of landscape transition science.

KEY ELEMENTS FOR LANDSCAPE TRANSITION SCIENCE

We propose that landscape transition science can support ILAs to transcend the shortcomings highlighted above, through a focus on practicing (Zanotti 2019) and proactively engaging (West et al. 2020) in meaningfully deliberative ways. We position landscape transition science as a way to engage with change processes in the critical boundary work spaces that landscapes provide (Arts et al. 2017, Zurba 2022). We suggest the purpose of landscape transition science is to enable transformative change among actors that shape values and justice. To address the key limitations above, we outline three key elements for landscape transition science. The sub-sections below outline how these key elements advance boundary work in support of sustainability transformations: (1) dealing with plurality and contestation, (2) relational praxis for more inclusive landscape science, and (3) reflexive learning for justice and sustainability in the context of continuous change. An interweaving element is greater emphasis on critically interpretive sciences to rebalance landscape sciences away from overly normative or techno-managerial approaches. A balance between critically interpretive and normative sciences helps to center landscape transition science on the fraught relationships and boundaries to improve deliberative foresight capabilities for enabling change toward sustainability transformations.

Pluralism and contestation

Sustainability transformations call for learning and implementation pathways that are grounded in pluralism. Meaning they ought to respond to diverse knowledges and values, be future-oriented, and be positioned to engage with deep structural economic and political dynamics and inequalities (Scoones et al. 2020). Pluralism does not represent a simple exercise but rather a long-term commitment to "actively listening" to different needs and values so that diverse positionalities can be incorporated to recognize complexity and challenge the existing structures. Pluralism should engage seriously with options that might be challenging, such as changing existing institutional structures and environments (Braun 2015*b*). For ILAs and allied sustainability sciences to heed this call, critically interpretive sciences, such as political ecology, are vital for shedding light on complexity, structural and discursive power, and politics and associated environmental relationships. Although these tensions are well documented, bottom-up movements attempting to bring about change continue to find resistance from growth-driven neoliberal forces, as powerful actors re-entrench status quo into underlying institutional structures.

An emerging emphasis on just transitions in the science and policy literature has prompted greater reflection on how actors, including scientists, engage with dimensions of justice in landscape transitions (Agyeman et al. 2002, Wijsman and Berbés-Blázquez 2022). In ILAs, these justice dimensions have been characterized by misaligned or contested value systems (Setten et al. 2018, Bayala 2023). This characterization is reinforced by scientific bodies such as IPBES, in which the understanding, distribution, interrelationships, and management of values underlies justice and sustainability as inseparable concepts (Pascual et al. 2023*b*). Who values what, how, and has access to values sustained in landscapes determines the way landscapes form and function (Cole et al. 2023). And although all decisions that materially impact upon landscapes are value laden (Meinig 1979), values and justice remain loosely defined, contested, and still under-interrogated concepts in landscape sustainability (Bieling et al. 2020). Values are entwined with worldviews, perspectives on what matters, life goals, and specific values toward nature and people (Kenter et al. 2019, Kenter and O'Connor 2022). Justice is often equated with fairness, but is also fundamentally contextualized to how peoples' experiences are tied to place. Accepting this pluralism and holding complexity are necessary to advancing landscape transitions.

Centering plural understandings of values and justice in landscape transitions responds to a growing acknowledgment of the social influences and representation that determine landscape accessibility and allocations (Forsyth and Sikor 2013, McDermott et al. 2013, Newell et al. 2021*a*). Transcendental or universalized concepts of sustainability (i.e., fixed or externally conceived value sets) often infringe upon local ways of knowing. Integrated landscape approaches have been criticized for being agnostic in their consideration of values and justice; a

"depoliticised approach" to achieving sustainability (Clay 2016). An example of this problem has been in how environmental and conservation sciences approach justice in narrow ways, such as focusing on distributional impacts (who gets what) from events or programs, or through "levels of participation" in conservation decision making and management of natural resources (Friedman et al. 2018). Critical examinations of power, justice, and values have begun to emerge in multi-stakeholder dialogs and deliberation (Larson et al. 2022), social change (Avelino 2017), and some landscape restoration and conservation initiatives (Abdurrahim et al. 2023, Siangulube et al. 2023). These experiences indicate ILAs have more to offer in deliberative and learning-based mechanisms that examine justice and values and promote transformations responding to pluralism.

Relational praxis

Relational praxis describes how landscape transition science is translated into action. The core tenets of landscape transition science—critical reflection and engagement with power, values, justice, and learning in place-based boundary work—call for a shift in how we act and engage. But foremost, relational praxis requires re-orienting how we respond to (i) institutional values and (ii) landscape values. Power relationships that give rise to dominant values and injustices tend to sit outside landscapes (such as neoliberal consulting knowledge economy and dominant political-economic interests). These power structures influence institutional values that guide how science is funded, selection of methods, merit criteria, and researcher reflexivity. Landscape values incorporate the broad and specific values that evolve within and through landscapes. Across both entities, transition science is disruptive. It is grounded in the notion that current socio-political structures are not fit to achieve required change and that research "in" rather than "for" development is required. Relational praxis seeks to immerse science and inclusively defined scientists in both understanding and shaping these drivers of change and making the socio-political-economic systems that influence values and justice explicit. Praxis must, therefore, include responding to institutional settings that shape science–policy–society–nature relationships, and critical and reflexive engagement within landscapes.

Carefully and respectfully engaging with institutions that govern science–policy–society–nature relationships requires a willingness to step outside traditional science boundaries—taking risks and (re)politicizing co-production (Turnhout et al. 2020). First steps might begin with institutional reflexivity: inviting scientists to recognize, analyze, and engage with the role of values within an institutional setting, and the identification of what constrains scientific practices toward justice (Dryzek and Pickering 2018, Leipold et al. 2024). For example, institutional reflexivity might entail asking questions that address systemic injustices to identify and make visible the voices and identities of those who experience harm and the need for healing and accountability (Forsyth et al. 2021). Making these relationships and injustices explicit is unlikely to be achieved through dominant reductionist and individualist approaches. Instead, scientists will need to draw on reflexive, place- and value-sensitive, and deliberative processes that challenge universal value and justice theories (Forsyth and Sikor 2013). For instance, Amartya Sen's comparative-justice framework may be more responsive to the rights and values of local landholders, who often have less agency in determining landscape change trajectories (Sen 2008). Indigenous science(s) frameworks emphasize relational accountability and seek to (re) build frameworks and methods and encourage reflection on the social position (positionality) of the knower in relation to ontological, epistemological, and ethical commitments (Wijsman and Feagan 2019, Harriden 2023). These relational approaches enable and privilege restorative justice in the consideration of institutional structures that inhibit or narrow transition pathways (McGregor et al. 2020).

Within landscapes, relational praxis invites an "ethic of care" and necessitates long-term commitment to addressing power dynamics in collaboration. This ethic of care recognizes and prioritizes different ways of knowing and forms of Indigenous relationality, which tends to remain marginalized in institutional settings (Gould et al. 2023). Integrated landscape approaches practitioners have attempted to build these capabilities with fuzzy cognitive mapping to reveal and communicate contrasting worldviews and narratives (Langston et al. 2024). Yet these tools alone fall short of comprehensively interpreting, prompting, or accelerating change toward more just and sustainable futures. A relational approach could build from these experiences to activate transformational capacities across individual, collective, and systems levels. For example, efforts to co-develop Indigenous science frameworks and place-based learning with local and Indigenous communities emphasize the process of relationship building and respectful communication with clear roles and relational accountability (Davidson and Henley 2007, Francis et al. 2012, Harriden 2023). This is essential for rethinking about how knowledge and government systems operate (i.e., spatial scales) and grounding critical dialog (beyond a shallow discursive commitment to desirable transitions and transformations) in shared action learning and sustaining ethical commitments to more just and bearable worlds (Ahmed 2007).

Although relationality emphasizes learning from Indigenous understandings, this ethic of care is also rooted in development practice. For example, Robert Chambers' original three pillars for development practitioners (behaviors, methods, sharing) emphasize how to: be nice to people, don't rush, embrace error, have fun, and relax (Chambers 1997). In terms of their transformative power, deliberative, messy, learning-oriented actions can shed light on the value systems tied to unsustainable or unjust outcomes and help to re-imagine futures where dimensions of justice and diverse values are centered in institutional settings (Riggs et al. 2023).

Critical interpretive sciences can deepen the intention of this ethos, providing epistemological framings for describing and making sense of relationships. Landscapes are where interpersonal exchange and lived experiences are co-constitutive of territorialization, i.e., the social (re)production of territory (Lombard et al. 2023). Territorialization processes offer opportunities for learning in response to more comparative, grounded, value-centric notions of justice (Sen 2008). Here, sustainability problems are more richly described as issues of value, explicitly confronting disparities and nuances of value recognition. From this perspective, reflecting on and operationalizing relational praxis under the guise of landscape transition science opens up realms of methodologies, partnerships, and entry points for deliberative, place-based boundary work. Landscape transition science is inherently tied to place and must recognize local knowledges and agency of place

to up possibilities for other ways of thinking and theorizing (Bawaka Country et al. 2015). Yet by also advancing institutional reflexivity, landscape transition scientists can play a vital role in advancing justice for the less empowered, ultimately, freeing up science and policy from the interests of some actors or groups that might restrain the scope of science or rush to implement ill-fitting solutions.

Learning for justice and sustainability

Ontological and epistemic justice in scientific frameworks and methods requires multi-directional and reciprocal learning (Fricker 2007, Turnhout 2024). However, learning is often approached in global conventions and scientific bodies in ways that are limited and disconnected from the messy contexts of where and how change happens. Insufficient attention to—or active deflection of the attention from—learning obscures diverse and pluralistic values, place-based knowledge, and power differentials in what counts as knowledge and whose knowledge counts. Ill-defined or externally directed learning objectives in large projects can privilege institutional and scientific knowledge, prioritizing accountability to donor's value sets and setting unrealistic expectations (Mosse 2004, Carrier and West 2009).

Learning is often about the transfer of the ideas, values, and technologies of those with power to those without. Policy experimentation can potentially encourage cross-boundary learning (Bos et al. 2013), but externally defined objectives and top-down approaches are more commonly identified (Sanders et al. 2017, 2020, Mattocks 2021). These approaches limit flexibility and learning opportunities (Leeuwis 2004), over-simplifying complicated project relationships riven with knowledge and power differentials. For example, excessive focus on local communities can be a result of a mismatch of values whereby the values of those with power are seen to be more important than those of the community, usually without explicit acknowledgement of power or knowledge differentials (Li 2008). Whereas bridging organizations and networks can support cross-scale communications and stakeholder analysis over time (Kurniasih et al. 2021), addressing power inequalities—including funding issues—requires greater consideration by scientific bodies, governments, and industry groups (Leys and Vanclay 2011).

Learning happens in places, in individuals, but is informed by spatio-temporal relationships (Vander Ark et al. 2020). Learning is situated in communities, institutional settings, and landscapes as relational places with multiple and contested meanings. There are differences in how learning is practiced and what people understand by "learning" in adaptive governance and landscape sustainability. For example, experiential learning explores subjective experience and practical action in how people learn, grow, and develop (Kolb 1984, Kolb et al. 2001) The idea of learning-by-doing in social learning (Leeuwis et al. 2002, Leeuwis 2004, Baird et al. 2014) is both a condition and outcome of collaborative relationships and interactions between different types of knowledge (Berkes 2009). Features of social learning related to leadership and collaboration in adaptive management are observed in "bottom up" yet discrete local community projects (Evans et al. 2020). Landscape transition science aims to explicitly connect and prioritize these features of learning to important capabilities of practical solidarity, humble inquiry, patience, and reciprocity in science–society–policy relationships.

Learning is interactive and has spillover effects—all landscapes are influenced by multiple learning pathways. This learning depends on and is shaped through relationships (van Kerkhoff et al. 2019). Qualities of listening, patience, humility, and relational accountability can foster reciprocal learning (Jasanoff 2007). Although potentially transformative, these qualities are hard to identify and often sidelined in favor of funding and publication metrics, instead of integration into policy making and collaboration processes. In recent assessments on formal education for sustainable development, approaches that focus on measurable results vs. those that emphasize individual empowerment may be reconciled with rebalancing instrumental and relational values and individual vs. collective action (Pettig and Singer-Brodowski 2025). A profound adjustment of research priorities, approaches, and associated institutional values for learning is, therefore, needed (Turnhout and Lahsen 2022). In the meantime, scientists with epistemic and other resource privileges can take braver steps to expose themselves to the risks of slower, humbler, more altruistic, "skin-in-the-game" (Taleb 2020) approaches. Although power differentials and intersecting inequalities are pervasive and poorly understood from a methodological perspective, critical literature explores the transformative role of alliances and cross-boundary collaboration, resistance, shared learning and reflexivity, learning from the past, and sustaining inclusive approaches (Wickenberg et al. 2022, Tschakert et al. 2023).

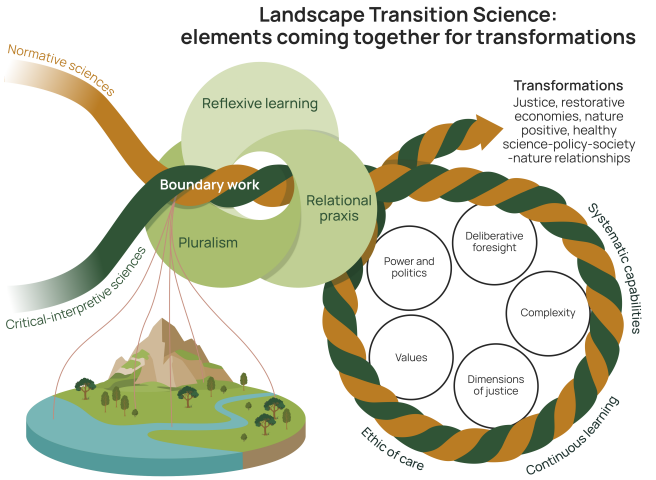
Elements coming together

Relational praxis embodies a paradigm shift in sustainability science, where knowledge, power, and experiences are considered to be situated within a process of unfolding relationships between and amongst people and nature, conservation, and extraction (West et al. 2020, Newell et al. 2021*b*, Beban and Banks 2023, Shackleton et al. 2023). Adopting a more explicit approach, boundary work involves relational thinking and practice that calls for deeper reflection on how these methodologies mediate boundaries among values, justice, and sustainability transformations. This lies at the heart of landscape transition science (Fig. 2) and redresses the limitations of a contested, overly normative, and techno-managerial approach in engaging with change. As such, ILA and allied sustainability science communities can reflect on the pluralism shaping contested conceptions of "how change happens", and to what extent it can be anticipated, planned, designed, induced, or even understood, and from what distance to engage (Easterly 2006, Sayer et al. 2008, West et al. 2020, Stirling et al. 2023)

Learning is key to relational praxis and involves reflexivity, positionality, situatedness, and responsibility, which necessitates reflection on ontological, epistemological, and ethical commitments (Russell 2010, Wijsman and Feagan 2019). Sultana (2022) emphasizes the transformative potential of solidarity and collective action in climate justice, rooted in the concept of praxis, defined by Freire as "reflection and action upon the world in order to transform it" (Freire, 2020:51). Longstanding calls for reflexive, situated, and engaged practices show these important connections for learning (Schlosberg 2007, 2013, Sultana 2021).

Understanding how institutional norms and scientific frameworks limit or obstruct transformation better enables us to position our science efforts and behaviors to achieving better

Fig. 2. Weaving different kinds of science together, enhancing them (through the elements), and anchoring them (to questions requiring greater attention), for a stronger kind of boundary work that leads to improvements in learning and adaptation for transformations.



futures (Turnhout 2024). Different learning levels, tiers, or loops emphasize connectivity rather than linear or hierarchical relationships. Single-loop learning corrects errors in judgement or routine, and this is positively associated with new skills and capabilities (are we doing things right?). Double-loop learning encourages questioning of values and policies (are we doing the right things?), whereas triple-loop learning builds critical awareness and reflexivity (how do we decide what is right?) (Tosey et al. 2012). This critical awareness and reflexivity are potentially transformative by questioning the assumptions in designs and protocols, enabling new insights and collective action (Leeuwis 2004, Armitage et al. 2008).

We argue that embracing learning, pluralism, and reflexive praxis in landscape transition science is characterized by qualities of listening, generosity, humility, respect, and inclusivity, in understanding the messy contextuality and relationships of past, present, and future. Manifesting these qualities is challenging. They require time and resources that are often scarce or fiercely contested. They require skills of listening to build trust and reciprocity that are not typically recognized and fostered in standard educational curricula (especially in educational systems that prioritize competition as a path to excellence). They can also make an individual researcher more vulnerable. These challenges warrant deliberate attention so that differently positioned scientists and practitioners can recognize and have strategies for navigating these situations, and so that institutions prioritize funding and operational arrangements that recognize and support these qualities.

CONCLUSIONS FOR LANDSCAPE TRANSITION SCIENCE

We began this article articulating a kind of science for integrating and advancing the benefits provided by multiple kinds of sustainability-oriented sciences. We describe this as landscape transition science; deliberative, place-based boundary work to advance sustainability and justice. We consider that integrated landscape approaches are inhibited by three key issues: contestation, dominance of normative and Western systems, and a lack of critical reflexivity. Greater attention to pluralism, relational praxis, and reflexive learning mediate these shortcomings. We highlight how through relational praxis coupled with institutional learning, ILAs and sustainability transitions sciences can constructively engage in tensions between normative and critically interpretive domains.

For landscape transition science, there is an important role for boundary-spanning methodologies in achieving inclusivity and integration. We, therefore, seek to foster such boundary work and reflexivity in our collective practices. And although we have not reviewed these methodologies here (see, Jesiek et al. 2018, Collie, 2021; Langston et al, 2024), we have articulated a science of place, people, and practices that can contribute to and build from a range of boundary-spanning methodologies. This paper provides a scope for science that engages with messy complexities, confronts issues of justice, and the failures to engage in deeper critical learning. For this, critically interpretive sciences must be more heavily interpolated to the more normative landscape sustainability sciences. We have sought to provoke questioning and learning about what it means for science to enable landscape transitions, and where ILAs fit in the larger fabric of sustainability science.

Relational praxis involves deliberately and reflexively interrogating, and proactively managing the boundaries blocking and connecting transitions to transformations. Relational praxis supports complexity, recognizes plural knowledge and values, and critically reflects on our individual positions and interpersonal traits as well as collective and larger system traits. Learning through relational praxis beckons behaviors that may not be readily rewarded in current systems that sustainability sciences aim to transition away from. This will require some courage and risk taking to learn and understand one's positionality and relational effects. Especially as this runs counter to the ego-building and livelihood defence mechanisms common to high-powered scientists and science institutions. The plurality of science for sustainability and justice requires humility, generosity of thought and action, patience, and willingness to acknowledge and grapple with uncertainty. It is tempting for scientists, practitioners, decision makers to "reduce complexity" into its constituent parts for rationalizing actions or decisions. "Simplicity on the other side of complexity" is an implicit mantra of many normative science agencies and institutions. But the world is a relational place full of complexity worth holding, one in which relational praxis encompasses these objectives through learning in the context of pluralism and relationships in place.

Advancing concepts for landscape approaches through landscape transition science invites individuals and institutions at the science–policy–society–nature interface to better grapple with questions of value, structural and discursive power, agency, and politics. By acknowledging landscapes as a place where human and nature values co-evolve, scientists can involve themselves in reframing questions away from externally driven change into analysis of locally specific and endogenous shifts in value and agency. Exploratory questions are important for addressing the identified limitations of ILAs at the interface of complex challenges to build institutional reflexivity. Exploratory questions of "how to accelerate a transition" become "how are values

collectively understood and co-produced with institutions in ways that enable sustainability and justice?" These are questions in response to the need for continual learning and adaptation in the face of uncertainty and systemic injustices, and can guide boundary work. Facilitating such a dialog opens space for deliberative modes of engagement that can build institutional and interpersonal capabilities to more justly define what is valued, how value accrues, and who decides. We think ILAs stand to benefit from greater efforts into relational praxis and transformative learning. Transitions guided by improvements to grounded listening, generosity, humility, inclusivity, respect, care, and reflexivity are ones for which we advocate. In sum, an emergent landscape transition science seeks to be disruptive by confronting the persistent problematic gaps across knowledge, practice, and political relationships and boundaries; to drive care-oriented transformations of our landscapes.

[1] These were facilitated by the main author in collaboration with the second and third authors to facilitate discussions through a half-day workshop (in-person in Canberra), tele-conference meetings, and email exchange over a period of approximately 18 months.

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Data Availability:

This synthesis piece is primarily conceptual—and any relevant data are open and fully available.

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