



# Pursuing Plurality: Exploring the Synergies and Challenges of Knowledge Co-production in Multifunctional Landscape Design

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Knowledge co-production has emerged as an important conceptual and processual tool in sustainability research addressing the needs of equity and inclusion. Indigenous communities and local people have engaged with the process of knowledge production, foregrounding their historical relationships with landscapes, based on their unique worldviews and knowledges. However, knowledge co-production, especially for multi-functional landscapes remains a contentious and complicated affair with enduring issues of power-sharing related to the different socio-political positions of stakeholders. This work explores the synergies and challenges in knowledge co-production for landscape re-design in the south Island of Aotearoa NZ through an assessment of the work done at the Centre for Excellence, Lincoln University. At this center, a multi-stakeholder team is grappling with designing a farm, through a transdisciplinary framework that attempts to include multiple worldviews. This work explores the various stages of the co-production process, analyzing the exchanges between various members as they prepare for co-production, the knowledge produced through this engagement, and how this knowledge is being utilized to further the goal of sustainability. Our results show that significant gaps remain between co-production theory and co-production practice which are a result of the mismanagement of the co-production process, the mismatch in the time and spatial scales of project goals, and the differences in the values and objectives of the different stakeholders. However, the process of co-production, though flawed, leads to the building of more open relationships between the stakeholders, and leads to some very meaningful knowledge products that address the multi-temporal and multi-spatial aspirations of multi-functional landscapes in Aotearoa NZ, while contributing to the broader scholarship on co-production in sustainability. Finally, both synergies and challenges prove meaningful when challenging the roadblocks to the inclusion of a diversity of worldviews, by clearly highlighting the places of engagement and why they were made possible. We suggest that knowledge co-production attempts in multi-functional landscapes around the world should attempt a similar assessment of their process. This can help build better relationships between scientists and IPLC, address disciplinary bias and marginalization of non-expert opinions, while also ensuring the relevance of the research to the multiple stakeholders of the land.

**Keywords:** co-production, sustainability, multifunctional landscapes, indigenous knowledge, cultural mapping

## INTRODUCTION

The production, dissemination, and assessment of knowledge for sustainable landscape management needs to address the aspirations of a multitude of stakeholders and timeframes. While in the past such knowledge was biased toward certain academic disciplines, professions and institutions, in recent years there has been an opening up of this space, to reflect the plurality of aspirations, methods, and worldviews (Cornell et al., 2013). In international sustainability research, the idea of knowledge co-production has been deemed an important tool that addresses both the politics of knowledge production and argues for more democratic and hybrid forms of governance (Miller and Wyborn, 2020). But, knowledge co-production is a contentious affair, with probable points of divergence (and convergence) among the many producers with existing power imbalances (Fritz and Meinherz, 2020).

Knowledge co-production, according to a recent work by sustainability scholars which explores different strands of participatory and transdisciplinary research, should be “context-based, pluralistic, goal-oriented and interactive” (Norström et al., 2020, p. 183). Additionally, as decades of work done with indigenous people and local communities (IPLC) has revealed, any meaningful attempts at co-production must challenge universalizing and essentialist assumptions of contextual concepts like “sustainability,” “vulnerability,” “transformation,” etc. (Parsons et al., 2016). It must also actively engage with decolonial methodologies which foreground inclusivity, ethics, and justice and advocate for reimagining historical accountability, responsibility, and the extraction of knowledge (Zanotti et al., 2020). Finally, recent work on co-production divides it into co-design, co-production and then co-dissemination and advocates for iterative and inclusive processes that attempt to wrestle with the plurality of knowledge systems, aspirations, and capacities (Tengö et al., 2017; Wyborn et al., 2019).

Knowledge Co-production for landscape design and management struggle with many of these considerations in the search for a process of collaborative stewardship which can facilitate power-sharing, negotiation, and conflict resolution (Cockburn et al., 2019). And, since landscapes are complex and dynamic entities that support a variety of processes simultaneously, their characterization as industrially planned monofunctional units, since the 1990s, has been replaced by the notion of multifunctionality (Cairol et al., 2009). This reflects the different aspirations of various stakeholders as well as the unique needs of place-based biotic and abiotic systems. The framing of multifunctionality, by integrating the production of ecosystem services with the management of sustainable production for human needs, also allows us to address the critical needs of human well-being, ecological health, and resilience in the face of increasing pressures of climate and land use (Fry, 2001; O’Farrell and Anderson, 2010).

While some scholarship has professed misgivings about multifunctional landscape design (Cairol et al., 2009; Knickel et al., 2009, 2018), others see great potential in it, especially when coupled with the emerging insights from knowledge

co-production (Slotterback et al., 2016; Guzmán Ruiz et al., 2017; Duncan et al., 2020). Our work builds upon such considerations and explores the potential for multifunctional landscape re-design, which foregrounds knowledge co-production, to provide solutions to some of our vital social-ecological crises, sometimes referred to as “wicked” problems (Bornemann and Christen, 2020), while addressing the aspirations of multiple regional stakeholders. By assessing the process behind the work done at a transdisciplinary research collective at Lincoln University’s Centre for Excellence focussed on Designing Future productive landscapes <https://research.lincoln.ac.nz/our-research/faculties-research-centres/centre-of-excellence-future-productive-landscapes-in-Aotearoa-New-Zealand>, we explore the process of co-production of knowledge.

While our work engages with recent scholarship on questioning Aotearoa NZ’s colonial roots of landscape design (Abbott and Boyle, 2019; Marques et al., 2021) and trysts with multifunctionality (Pearson, 2020; Tran et al., 2020), it is deeply inspired by the powerful and ongoing mobilization the place-based cosmologies of the Māori people, the autochthonous/indigenous people of Aotearoa NZ (Lilley, 2018). Specifically, we work with the Mauriora Systems Framework (MSF) which is a processual framework emanating from Mātauranga Māori cosmology and Kaupapa Māori practice (Matunga et al., 2020).

Ultimately, guided by the two following research questions we explore the process of knowledge co-production in the re-design of a multi-functional landscape:

*What are the major synergies and challenges that emerge during knowledge co-production when attempting to design and manage a multifunctional landscape in Aotearoa NZ?*

*How do they challenge or support existing research on knowledge co-production for sustainability?*

This paper is organized in five sections below. In the first section, we present a literature review that examines some of the recent literature on multifunctional landscape design, knowledge co-production in sustainability, and Māori knowledge. In the next section, we provide an overview of our methods. We then present an overview of the project from Lincoln University, dividing the sections into co-design, co-production, and co-dissemination. In the fourth section, we answer our research questions, exploring the challenges faced during knowledge co-production, focussing on the major synergies and discords. We conclude the final section with an identification of the major limitations of our work and a vision for its future development.

## LITERATURE REVIEW

### Multifunctional Landscapes

Multifunctionality provides a useful prism for the planning and design of landscapes that are resilient to a variety of social-ecological challenges and address the aspirations of a wide variety of stakeholders (Cockburn et al., 2019). Multifunctional landscapes emerge as spaces that address the needs of agricultural production while enhancing vital ecosystem services and serving

multiple institutional needs (Song et al., 2020). Additionally, due to the multiple scales that populate landscapes it also helps knowledge producers and managers deal with the limitations of the farm, city, or region. Ultimately, multifunctional land use ushers in new institutional arrangements and new relationships between knowledge producers and managers which biases more horizontal and lateral connections instead of vertical ones. In re-imagining these linkages there is also a significant degree of spatialization that is infused into our knowledge and management practices (Wilson, 2009; Slotterback et al., 2016; Cockburn et al., 2018).

The opening up of the planning and design space to such plurality of aspirations and discourses brings with it significant concerns around the management of such diversity to ensure the objectives of the overarching landscape plan (Pinto-Correia et al., 2019). While in the past this plurality was managed through a productivist, economic lens, mirroring cost-benefit negotiations between different monetary evaluations of the land (Yoshida, 2001; Caird et al., 2009), in recent years, such thinking has been challenged by a more holistic perspective that pursues social-ecological well-being through synergies across economic, ecological and cultural goals (Spataru et al., 2020). Such framings have received further support due to the various manifestations of the Anthropocene and its current and probable future impacts on our agricultural systems (Gorman et al., 2020). Additionally, recognizing the different subject positions occupied by different stakeholders and the varying amounts of power they represent, are seen as vital in understanding the decision-making pathways of multifunctional land use (Duncan et al., 2020; Fagerholm et al., 2020; Jackson et al., 2021). Such an understanding has highlighted the need for pursuing collaborative landscape stewardship in multifunctional landscapes and the lack of qualitative, place-based literature on the factors influencing such collaboration in contentious contexts (Cockburn et al., 2019).

In Aotearoa NZ, akin to other settler colonies, land management is a contentious issue (Te et al., 2019; Ojong, 2020). In recent years there has been a recognition within the literature of the historically ongoing resistance by indigenous communities, the Māori, to colonial and industrial visions of landscape design and management (Marques et al., 2018; Abbott and Boyle, 2019). Māori communities and scholars have instead proposed landscape design and management rooted in their culturally derived worldview and knowledge system, *mātauranga* Māori, which foregrounds *whakapapa*, a genealogical web that connects humans to the non-human world (Harmsworth et al., 2016; Spiller et al., 2020). Therefore, the valid inclusion of the *mātauranga taiao* (Māori environmental knowledge) and the *mātauranga-a-iwi* (place-based knowledge of individual tribes) to inform the *tikanga* (cultural protocols and habits) required for the production of knowledge, is at the forefront of Māori concerns about land stewardship and sustainability (Stevens et al., 2016; Kitson et al., 2018; Wilkinson et al., 2020).

## Knowledge Co-production in Sustainability Science

Knowledge co-production in the arena of sustainability science, natural resource management, climate change, and other areas

of policy focussed research has emerged as a response to the complexity and dynamism of our social-ecological systems, the challenge from different social actors regarding their lack of representation in reductionist knowledge frameworks and to ensure that decision-making pathways are equitable increasing the potential for operationalization of the knowledge produced (Grove et al., 2015; Galvin et al., 2016; Muccione et al., 2019). The roots of co-production are rooted in methods and concepts like participatory action research, transdisciplinary research, postnormal science, and civic science, whose overarching goals are the creation of iterative and inclusive processes, which allow for the development of common ground and trust while building new capacities to address complex problems and ultimately, enhancing the usability of scientific information beyond the academy (Wyborn et al., 2019).

While advocates for co-production tout its various benefits, there is a significant critique of the process, which highlight the troubles with finding the common vocabulary to define objectives and goals, the enduring legacies of power that destabilize and depoliticize, the struggles with sustaining co-production beyond the initial co-design phase and the decay of trust due to the inability of institutions to address the emerging transformative conclusions (Lemos et al., 2018; Turnhout et al., 2020). Therefore, co-production is not a silver bullet panacea, and there remain significant issues in understanding how long-term co-production can be sustained and the problems that arise when transitioning from co-production theory to co-production practice (Jagannathan et al., 2020).

The practice of co-production is often the focus in projects involving indigenous communities (Tengö et al., 2017; Hill et al., 2020; Zanotti et al., 2020; Wyborn et al., 2021). In recent years multi-scalar research initiatives such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Convention on Biological Diversity (CBD), and the Intergovernmental Panel on Climate Change (IPCC) have all attempted to engage with various instances of co-production with indigenous and local knowledge (ILK) to varying degrees of success (Ford et al., 2016; Tengö et al., 2017; Schröter et al., 2020). Additionally, more place-based initiatives have also been attempted, often concerning climate adaptation, conservation, urban planning, natural resource management, and extractive industrial development planning (Bezner Kerr et al., 2018; Mazzocchi, 2018; Persson et al., 2018; Reiter, 2018; Upton, 2019; Lauter, 2020).

In Aotearoa NZ there have been similar mobilizations over the past decade, often using juridical mandates enshrined in the bicultural goals of the nation, especially the Treaty of Waitangi (Dominy, 1990; Garner, 2017; Morgan et al., 2019). In the process, Māori scholars and communities have challenged the “ongoing privileging of one knowledge system and suppression of the other” and questioned knowledge production objectives that don’t actively pursue a policy of *mātauranga* revitalization in support of Māori self-determination and rights (Bishop, 1999; Leonie et al., 2002; Broughton and McBreen, 2015). This robust culture of seeking knowledge equity as an inseparable component of cultural well-being has led to the creation of multiple approaches, tools, and frameworks that center *mātauranga* and

**TABLE 1** | Breakdown of the different goals, methods, and stakeholders of the teams within the COE.

Team	Goals	Methods/tools	External stakeholders
Social	To gauge interest within the regional farmers for incorporating the redesigns being proposed by COE and to ascertain current anxieties and aspirations of farmers	Semi-structured interviews, surveys, literature review of current literature	Farmer collectives, primary industry organizations, Beef/Lamb/wool producer groups
Pastoral Production/Landscape Health	To redesign a pastoral landscape that enhances pastoral livestock production while addressing ecosystem service needs of the land	Place-based biophysical data collected on-site, LIDAR data, land use/land cover data from the national database (LINZ)	Remote sensing and digital analytics companies, Natural Resource management collectives, Agroecological evaluation companies
Te ao Māori	To redesign an agricultural landscape using the principles of mauri enhancement and by tracing a historical genealogy of land use and ownership	Maori cultural mapping using the MSF framework, using base maps from <i>Kā Huru Manu</i> , The Ngāi Tahu mapping project	Various regional maori <i>iwi</i> , Ka huru Manu, <i>Papatipu Rūnanga</i>
Design	To create farm-scale design plans by engaging with multi-stakeholder aspirations and transdisciplinary data sets	GIS data, spatial analysis, design thinking, landscape architectural methodology	Farm managers, data visualization and analytics institutions, primary industry

*kaupapa* Māori (Marks, 2015; Lilley, 2018; Stevens et al., 2020). One such tool is the Mauriora Systems Framework (MSF), which was developed to support cultural responsible environmental decision making by delineating the four pieces which create environmental decision making: *Taonga* (material and more-than-material resources of value), *Tikanga* (cultural practices and actions), *Kaitiaki* (stewards and decision-makers), and *Mauri* (the life force that is inherent in all living beings). The MSF initially developed in the 1990s, was to ensure that Māori spiritual and cultural values were recognized in evaluation attempts and that place-based Māori community interests were represented in various aspects of land and environmental knowledge production and governance. The MSF is centered on the idea of *mauri*, which is the lifeforce that is within all living things and joins all the elements in the world, creating a holism. The frameworks' primary objective is to protect, maintain and enhance the mauri of the system, as considered to be valid by *kaitiaki*, consistent with the *tikanga*, to achieve a state of *mauriora*: well-being (Matunga et al., 2020). The way this framework functions is that an external proposition (science/governance-related plan, policy, project, etc.) activates the system. The scope of the proposal helps inform who specifically within the Māori community will be impacted by this. Once the stakeholders have been identified, their *kaitiaki* evaluate the plan concerning their *tikanga* and explore possible effects to the mauri of their *taonga* (tangible and intangible objects of value). This evaluation forms the foundation of their engagement with the process (Matunga et al., 2020). The MSF rooted in *te ao Māori* (Māori worldview) grants autonomy and control to Māori communities over management, planning, and knowledge production practices which allow the Māori as a historically marginalized IPLC to assert their opinion on a plethora of issues.

Ultimately, such questions of autonomy, sovereignty, and marginalization remain unresolved in much of co-production research (Turnhout et al., 2020). Scholars and practitioners have suggested different reasons for this, however, there is also

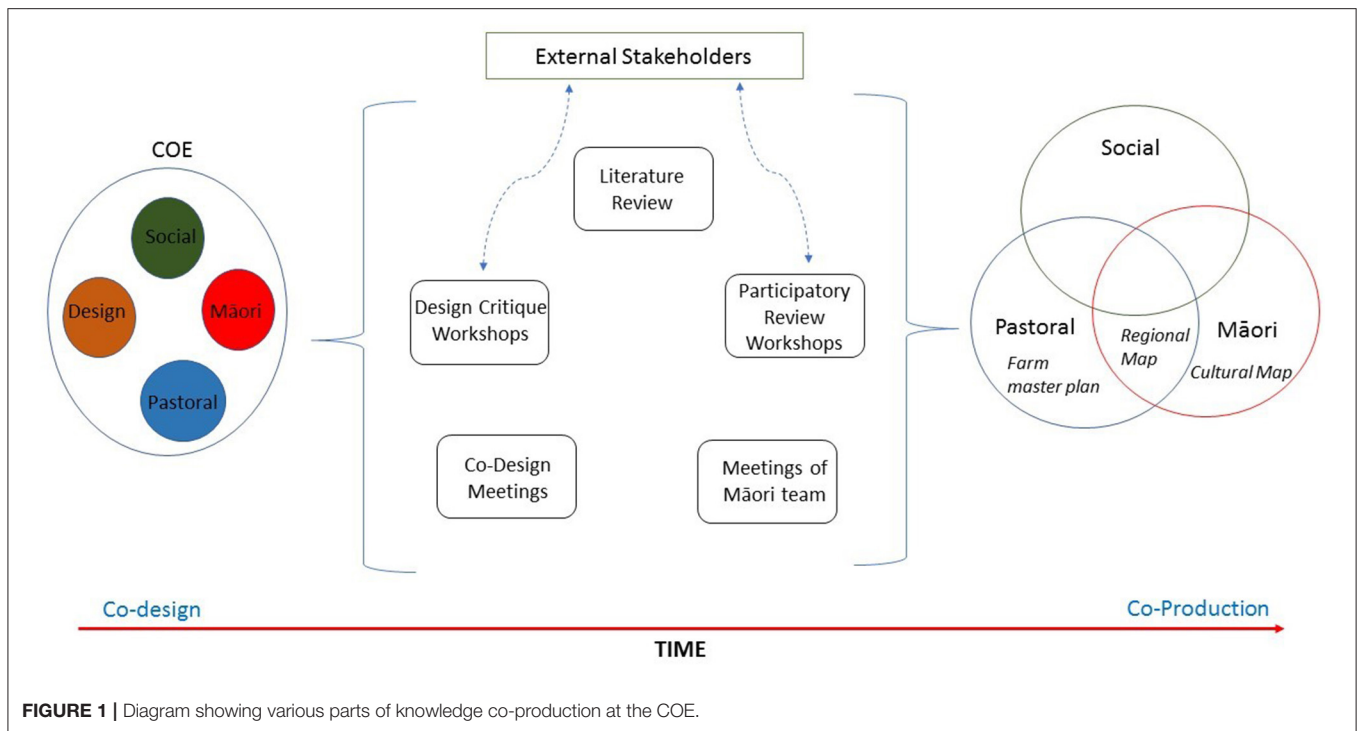
an identified need to engage with the existing principles of knowledge co-production and identify not just moments of synergy and success, but also divergences, challenges, failures, tensions, and trade-offs (Polk, 2015; Wyborn et al., 2019; Norström et al., 2020). Such an undertaking can help reveal the limits of our methods while identifying the mismatches between our ideological goals and the functional (and institutional) capacity for such conclusions to be operationalized.

## METHODS

### Situating the Study

The corresponding author of this paper (RC) was a post-doctoral fellow hired by the COE in 2019 to work on qualitative data collection, engagement with farmers, and to assess the process of knowledge co-production being attempted. Different groups were set up within the COE to focus on the different disciplinary aspirations and the different thematic needs. Broadly defined there were four teams: *the social team*, *the pastoral production and landscape health team*, *the te ao Māori team*, and *the design team*. The team goals within the broader umbrella of the center were given in **Table 1**.

RC was a part of the social team as well as the Māori team and distributed his time between doing in-depth literature reviews, collecting qualitative social data through interviews with regional farmers, conducting ethnographic participatory observation during the various meetings of the COE, and working with other members of the Māori team produce cultural maps and collaborative maps. The transdisciplinary and multi-stakeholder team, which was created at the COE at Lincoln University, over the last 2 years, has been engaging with some critical issues related to exploring and designing multifunctional landscapes in Aotearoa NZ. The objectives of the center are to transform existing landscape management practices through multi-functional landscape design that incorporates systems thinking, landscape ecological principles, and *mātauranga* Māori



**FIGURE 1** | Diagram showing various parts of knowledge co-production at the COE.

knowledge. Additionally, to explore these questions the COE has attempted to pursue a process of co-production. However, this vision is a product of various institutional realities of the small, land focused university it is embedded within, the politics of the primary production and land management industry in Aotearoa NZ, ongoing negotiations between Māori and the state regarding their historical claims and the impacts of the Covid-19 pandemic. For example, the knowledge co-production process we discuss in this paper is for the re-design of a farm located in the high country of the South Island of Aotearoa NZ. Mt. Grand station is a Lincoln University-owned high country sheep farm located in the upper Clutha basin in Central Otago (<https://www.topomap.co.nz/NZTopoMap/nz21374/Mount-Grand/>). The past and the future of the region this farm is in elicits very different aspirations from different stakeholders. For the descendants of European farmers who colonized this land, it is a generational transfer of both culture and wealth of which they are fiercely protective (Swaffield and Brower, 2009). On the other hand, for the indigenous Māori, the high country is unceded, stolen land, which was taken by the colonial state through institutional trickery and whose social-ecological systems have been exploited and ruined by colonial land management. The reclaiming of this land under indigenous stewardship is a key part of Māori sovereignty claims in current day Aotearoa NZ (Yates, 2021). Such contentions were (and are) in the foreground of discussions within the COE regarding the future of the farm as a multi-functional landscape. This data for this paper reflects these deliberations.

Within the COE, the scholar leading the Māori team is a member of the Māori *iwi* (tribe), whose historical territory

and current land claims the farm in question sits within. Additionally, he also has close relations with the *iwi* whose land the university is situated on. Given these socio-political ties to the involved indigenous stakeholders, the Māori team was given access to spatial and cultural data which were instrumental in the building of the cultural maps. This access to the regional *iwi* data was given only to the Māori team and therefore, it was only the final maps that were brought to the bigger COE collective. Ultimately, the usability of the produced maps was seen to be a vital reason for this access, given the ongoing negotiations between the Māori and the colonial state through the Treaty of Waitangi (Te et al., 2019).

### Data Collection

The data for this paper was gathered through a mixed-methods toolkit which consisted of mining literature on knowledge co-production to identify salient features of such process from attempts across the world; semi-structured interviews with some regional farmers; ethnographic participatory observation during group meetings at the COE and also during specific thematic group meetings; and ethnographic participatory observations during multi-stakeholder design critique workshops and participatory review workshops (Figure 1).

The data collected for this paper does not reflect the full array of methods utilized at the COE by the various teams to perform their tasks. Instead, the data collection methods mentioned in Table 2 address the question of assessing the knowledge co-production at the COE as mentioned before.

**TABLE 2** | Mixed-methods data analyzed for this paper.

No.	Name	Number	Definition	Objective
1	Literature review for guiding stage 1 of Co-design (section Stage 1 of Co-design)	30 peer-reviewed journal articles/book chapters	We conducted a systematic review of literature emerging from different disciplines with a focus on more recent (2000–2021) scholarship on knowledge co-production in sustainability and environmental/land management with a focus on projects that attempt IPLC collaboration	To ascertain the state of current scholarship and to identify key concepts/tools of knowledge co-production
2	Co-Design Meetings held at the COE which inform the Stage 1 and 2 of the Co-design process (sections Stage 1 of Co-design, Stage 2 of Co-design)	20 (These varied in number from 5 to 16 people per session)	These were structured and semi-structured meetings often moderated by 1–3 people, held in conference rooms on the Lincoln campus. These were attended by faculty affiliated with the COE, primary industry collaborators, designers, and other stakeholders	To foster transdisciplinarity through collaborative discussions about values, goals, objectives and to proceed with the redesign of farms using a multifunctional, multistakeholder framework
3	Participatory review workshops	2 (These included 9 in one setting and 16 in another)	These workshops which involved engaging with stakeholders with place-based knowledge about the land we were attempting to redesign were used to create a set of topics and sub-topics that were of importance for the social-ecological well-being. These workshops used strategies from participatory research (Fazey et al., 2020)	To engage with stakeholders beyond the COE to gather their opinions about whether the research goals and design objectives of the COE addressed important current and future regional issues
4	Semi-structured interviews with primary producers	7 (A lot more of these were planned but had to be abandoned due to COVID-19 related complications)	These interviews were with different farmers (dairy, mixed crop, sheep, and beef) and were conducted at their homes, on Lincoln campus, at the farm, and over the phone. They were covered by the requisite Institutional Review Board approval for research with human subjects.	To engage with individuals and communities engaged in primary production to understand their opinion about the work being developed at the COE and their aspirations/anxieties about their livelihood
5	Design critique workshops	2 (One of these was attended by community stakeholders and the other was for university administrators)	These were discussion-group driven events, which were moderated by 1–3 members of the COE, and were to collect opinions on ongoing efforts of the COE, and were held at a high country station (sheep/deer farm) and on the university campus.	To engage with primary industry stakeholders, natural resource managers, and university administrators to solicit their opinions about our initial redesign attempts for the farms
6	Meetings of the te ao Māori team	12 (These were attended by the 3–5 people who were directly involved with the Māori theme of the COE)	These were meetings held on the Lincoln University campus and in and around Lincoln town to work on realizing goals, objectives, and eventually methodologies to complete the work.	To come up with a strategy that would allow for the successful completion of the cultural mapping project, provide spatial connections with the farm-scale mapping and create a tangible product to take to regional iwi for critique

## Data Analysis

The analysis of data for this paper was done in three separate ways. First, the knowledge production literature that was reviewed was mined for conceptual insights which could help

guide the COE's creation of a process for knowledge co-production. These insights were then used by COE members as starting points for discussions around how to perform contextual knowledge production in the specific context of the

COE, the region where the farm was located, and financial and temporal constraints.

Second, ethnographic participant observation notes (Yang and Gilbert, 2008; Kansanga and Luginaah, 2019) were taken at the co-design meetings, design critique workshops, and participatory review workshops and meetings of the Māori team. These were transcribed and qualitative coding was done followed by thematic coding in two rounds (Nowell et al., 2017; Matuk et al., 2020). The first round identified important thematic categories and helped situate the data within the four most prominent themes: *values, inclusion, methods, and engagement*. Conversations of values focussed on more abstract ideas of what the project was about and what our goals were and explored questions of accountability and equality. Conversations of methods focussed narrowly on the how what and why of the different tools that we were using to address the question at hand. Conversations of inclusion focussed on the involvement of stakeholders beyond the academy, while conversations of engagement explored how different disciplinary and epistemic collaborations (and dialogue) could be facilitated within the group, while in a way this could be seen as a subset of methods, it emerged as its category given the importance it was given during our process and our overarching goal of collaborative knowledge production. In the second round, we probed more into, what we defined as, moments of *synergy* and *challenge* during the meetings. Synergy was defined as an exchange where the speakers agreed and added to each other's opinion while a challenge was an instance where an opinion was challenged, and the exchange ended with a resolution. We mined the data for such exchanges and summed them up by the teams the individuals belonged to. The individuals engaged in these exchanges were tagged by their affiliations to the four intra-COE teams.

Third, the knowledge products that came out of the co-production process at the COE were contextualized by presenting the specific aspirations and ultimately the transdisciplinary and multi-stakeholder process, which they emerged from.

## RESULTS

The results of the knowledge co-production process can be divided into two main parts. The first explores synergies, challenges, and learning outcomes from the process of knowledge production which responds to the overarching exploration of knowledge co-production in sustainability research which is the central objective of this paper. We also present certain knowledge products in a second part which are the conceptual artifacts that emerged from this process. Since the goal of this paper is to *assess the process of knowledge co-production* and not simply to present products from the co-production process, the relevant methods used to create such products (cultural mapping, spatial landscape design) are not explored in detail as part of the overall methods of this paper. Therefore, the results presented below are the ones that explore the process of production of knowledge itself within the COE, with some relevant knowledge products presented as emerging conceptual and material conclusions from such knowledge-coproduction.

## Synergies, Challenges, and Learning Outcomes From the Knowledge Co-production Process

During this initial phase, the framing of projects was significantly disciplinarily biased, with individual teams suggesting overarching objectives, and the co-defining of the problem space was restricted to the very abstract. While logistical matters surrounding project goals, delivery dates, and probable methodologies were rigid and inelastic within each team, there was a dialogic progression toward more perforated objectives and tools. This process emerged through design meetings held at the COE from *August 2019 to March 2020*. These meetings were recorded, minutes were taken, and detailed notes compiled. This stage of knowledge co-production is termed Co-design.

In the next few sections, we explore the co-design meetings to categorize the conversation under the four themes mentioned before and to highlight moments of synergy and challenge which emerged during the process. Additionally, we also explore certain key activities undertaken by the specific teams during these stages of the process.

### Stage 1 of Co-design

The two stages division of the Co-Design process emerged from the clear demarcation between the initial stage when discussions centered on goals and objectives of the project vs. the second stage which proceeded from a more concrete organization of capacities, actors, and goals that the COE wanted to pursue.

During stage 1 of the Co-design, a literature review was compiled from which certain important and useful concepts were identified (**Table 3**). This was done to situate the work being attempted at the COE in the broader scholarship and methods of co-production and to identify relevant ideas which could be explored in the regional context of Aotearoa NZ.

Using insights from the scholarships presented in **Table 3**, through the process of co-design meetings, we decided upon the following salient features (**Figure 2**).

These salient features attempted to capture the diverse aspirations of the group within a few guiding ideas. Plurality was nominated to encompass the needs of transdisciplinarity but also address the IPLC knowledges which did not neatly fit within the expert-driven knowledge systems of the university. Accountability and Māori Self Determination were both nominated to address the historically exploitative relationships between scientific practitioners and Māori communities and to safeguard knowledge diversity and usability within the projects (Tengō et al., 2017). Finally, Multi-Faceted goal-setting and Contextual Engagement and Integration were nominated to ensure that the process remained aware of the temporal and financial constraints while facilitating multi-stakeholder engagement which was more than mere tokenism (**Figure 3**).

### Important Outcomes

- While it was deemed vital to engage with Māori and regional farmers more intimately during the early design process, relevant stakeholders noted the burden this would represent. Especially given existing engagements between such groups and academic projects. It was decided that the initial co-design

**TABLE 3** | Identifying guiding principles and goals for knowledge co-production.

No. References	Concepts/tools
1 Wyborn et al., 2019	<ul style="list-style-type: none"> <li>• Recommendations for the Co-production process</li> <li>• <i>Preparing for co-production</i>: During this early phase, <ul style="list-style-type: none"> <li>• Ensure representation from all relevant stakeholders with attention to culturally important entities and typically marginalized communities</li> <li>• Carefully select a facilitator for the process</li> <li>• Create relationships between horizontal actors</li> <li>• Consider venue and meeting materials and be explicit about the decision-making process, highlighting responsibility, accountability, and sharing</li> </ul> </li> <li>• <i>Managing co-production</i>: During this phase, <ul style="list-style-type: none"> <li>• Ensure openness and flexibility</li> <li>• Focus on broad, cross-cutting issues</li> <li>• Carefully consider power dynamics</li> <li>• Facilitate capacity building</li> </ul> </li> <li>• <i>Sustaining co-production</i>: To ensure the long term viability, <ul style="list-style-type: none"> <li>• Establish non-exploitative and non-extractive relationships between actors</li> <li>• Explore options beyond the budgetary constraints of current work</li> <li>• Focus on pre-existing institutional context and identify relevant scales that can be explored further</li> </ul> </li> </ul>
2 Norström et al., 2020	<ul style="list-style-type: none"> <li>• Principles for Co-production in sustainability research</li> <li>• <i>Context-Based</i>: Situate the process in place-based realities</li> <li>• <i>Pluralistic</i>: Directly and advertently recognize the multiple ways of knowing and doing</li> <li>• <i>Goal-Oriented</i>: Articulate clear goals that are shared, meaningful and achievable</li> <li>• <i>Interactive</i>: Facilitate ongoing learning among the different stakeholders through different engagements</li> </ul>
3 Polk, 2015	<ul style="list-style-type: none"> <li>• Challenges for transdisciplinary co-production</li> <li>• <i>Capturing Multiple Framings</i>: Address through joint problem formulation and design</li> <li>• <i>Integrating knowledge diversity</i>: Address through co-generation of data, joint analysis, and implementation</li> <li>• <i>Evaluate</i>: Address through formal evaluations of processes and impacts</li> </ul>
4 Jagannathan et al., 2020	<ul style="list-style-type: none"> <li>• Outcomes from Co-production should be divided into, <ul style="list-style-type: none"> <li>• <i>Scope 1 outcomes</i>: These center around benefits from the production and dissemination of decision-relevant knowledge and services</li> <li>• <i>Scope 2 outcomes</i>: These are more ambitious and may transform societal power structures and political systems and re-order science-society relationships</li> </ul> </li> <li>• While Scope 1 outputs are easier to measure and document, it is often the Scope 2 outcomes that are harder to achieve but are often being pursued as the end goal for co-production.</li> </ul>
5 Broughton and McBreen, 2015; Wilkinson et al., 2020	<ul style="list-style-type: none"> <li>• Knowledge co-production with Māori communities and actors must, <ul style="list-style-type: none"> <li>• Recognize <i>tino rangatiratanga</i> and self-determination of the Māori</li> <li>• Include restoration of the material and cultural systems and artifacts</li> <li>• Prioritize projects that are most likely to support <i>hapu</i> and <i>iwi</i> to develop and practice <i>matauranga</i></li> <li>• Identify mutual research needs and benefits</li> <li>• Identify potential challenges and risks of researching the cultural interface</li> </ul> </li> </ul>

process would be decided by a core group of COE members with input from regional stakeholders once the overarching objective of this work was more concrete.

- The team was split into various smaller groups, with theme leaders, decided by disciplinary/epistemic/ideological boundaries. This decision reflected the early aspirations of an expert-driven, tentatively co-produced design which was iteratively transformed through dialogue toward a more plural knowledge framework, foregrounding mātauranga Māori sovereignty.
- While questions of “value” were the most contested and challenging, they were often tabled, given the constraints of time, and the group was corralled by theme leaders toward questions of method and probable outputs.
- The tools of GIS, spatial analysis, and Geo-design emerged as a powerful knowledge production and management tool during these early conversations. This presence of a potential favored tool kit also catalyzed the creation of different groups within the COE team. It was decided during this time, to use the framing of different ontologies, cosmologies or worldviews, and different epistemologies to divide the COE methodology into the constituent, relational, and *Te ao Māori* analytical pathways. The worldviews described as Relational, Constituent, and *Te ao Māori*, relate, respectively, to ontological differences between the critical social sciences/humanities, positivist science, and indigenous knowledge. Therefore, the relational worldview is guided by theoretical insights from constructivism, post-humanism, post-materialism, post-modernism (among others), that question the reality of human-nature binaries, while imagining how entangled relationships between different subjects and processes exist at material and more-than-material levels (Whatmore, 2006; Castree, 2015; Rocheleau, 2016). The constituent worldview is rooted in the positivist ontology which often claims (with some caveats) that truth and reality are free and independent of the viewer and observer and can be understood through repetitive experimentation which quantitatively adds up the sum of all the parts. Much of natural and physical science research is embedded in this paradigm which often seems quite oppositional to the relational worldview (Patterson and Williams, 1998; Meissner, 2016; Ely et al., 2020). Finally, the *Te ao Māori* worldview represents place-based indigenous engagements with various aspects of reality (as mentioned before).

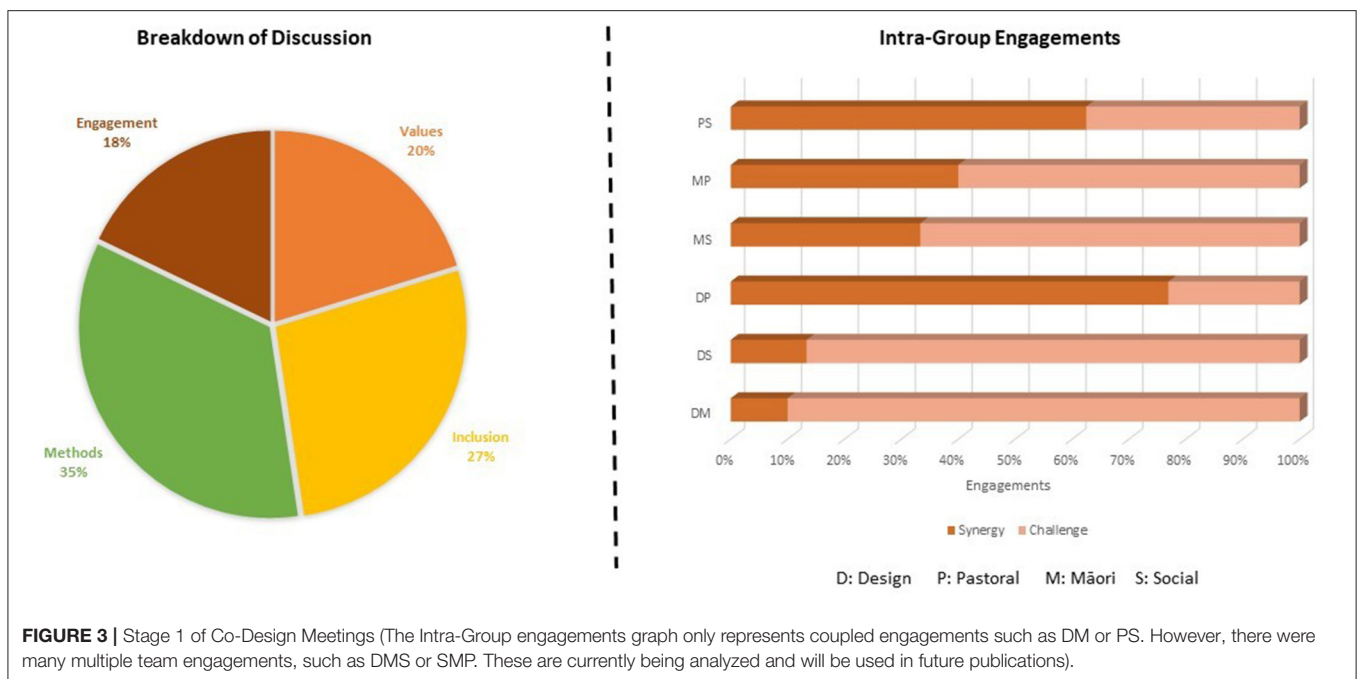
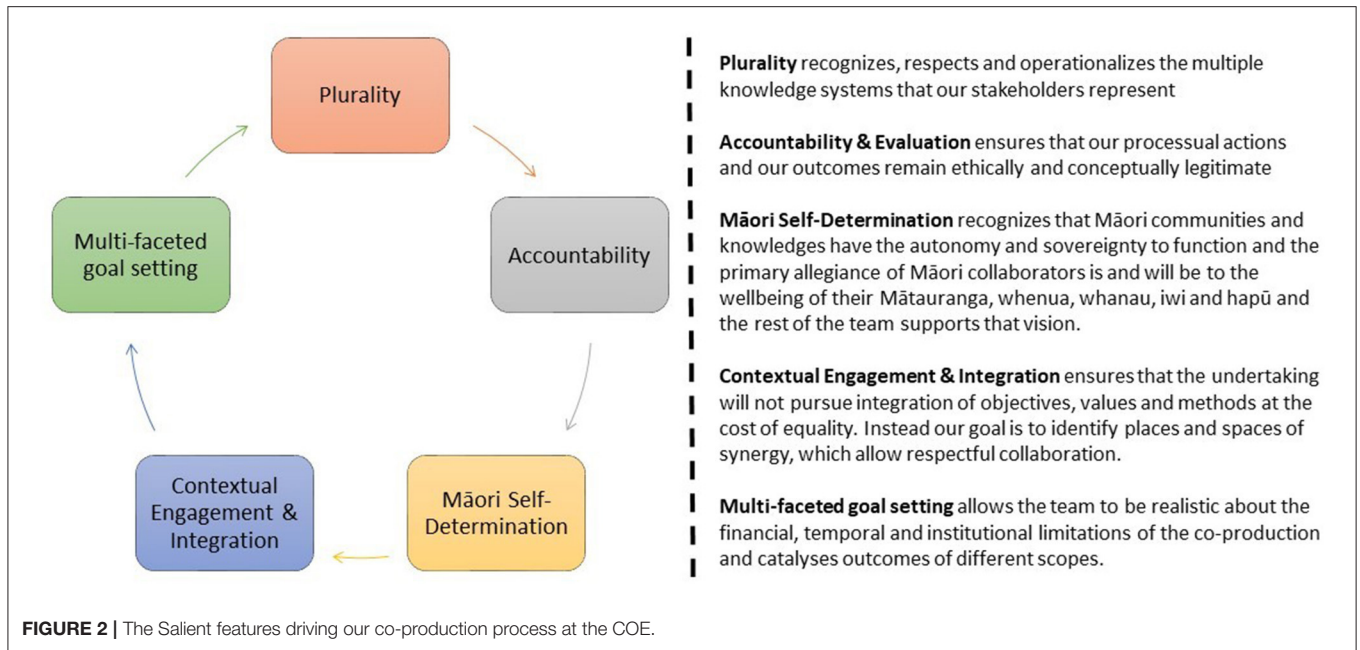
### Stage 2 of Co-design

Stage 2 of Co-Design proceeded with an identification of the technical and the manpower capacities of within and across the different teams of the COE, driven by the overarching conversations from stage 1 of Co-Design (Figure 4).

### Important Outcomes

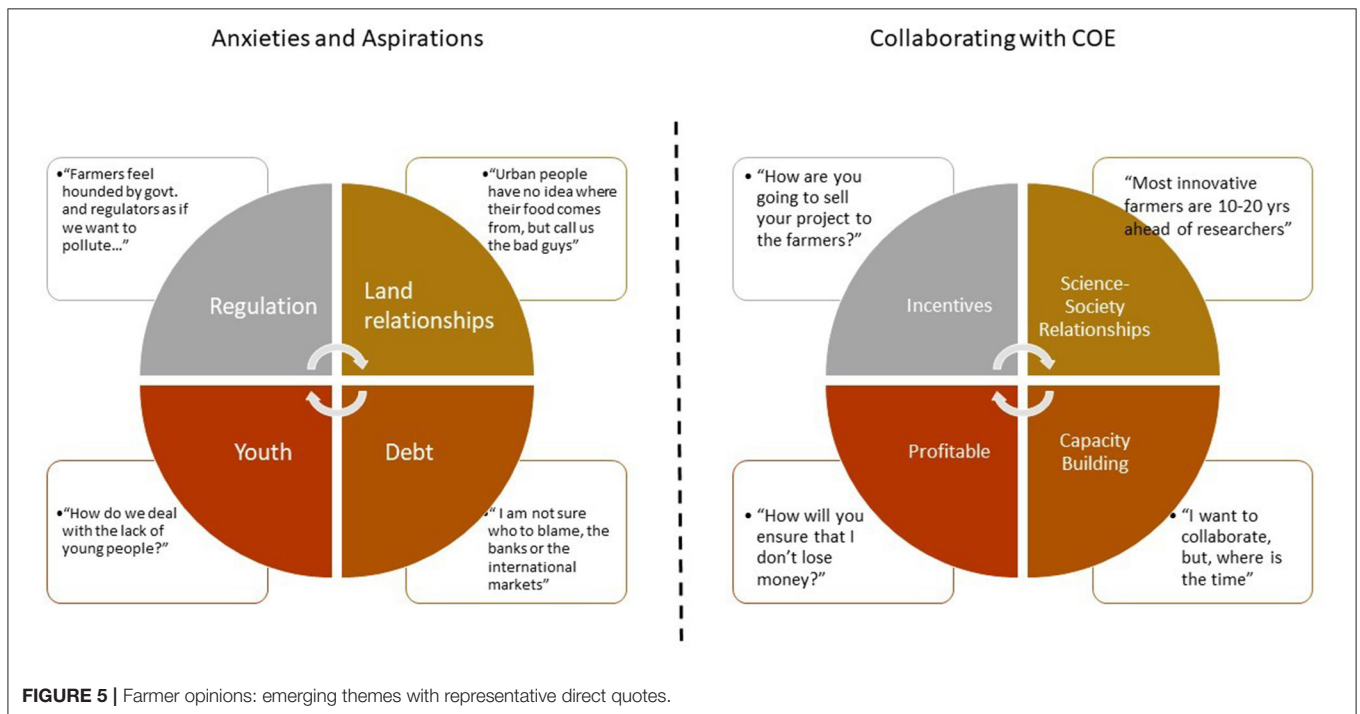
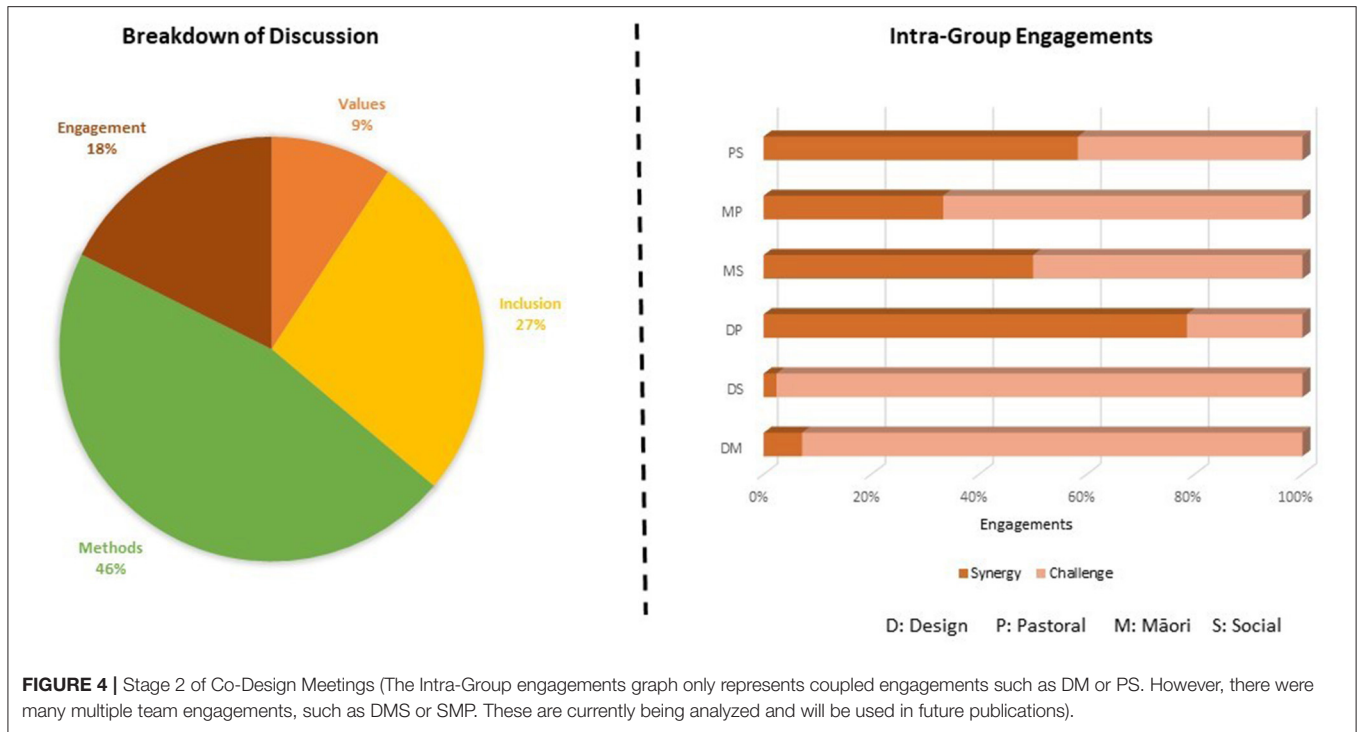
- The second stage of the Co-design process consisted of a lot more conversations around the inclusion of other stakeholders and a move toward exploring knowledge co-production. However, despite this objective, most of the focus remained on finalizing the methodology for the work, without much focus





- on how the transdisciplinary engagement across different internal teams would be facilitated and managed.
- While there was some discussion about more rooted values, the group seemed to have settled on a set of values which while not without contestation in its entirety, allowed for the project to move ahead.
  - As the COVID-19 pandemic was beginning to show up on the group’s radar certain decisions were taken regarding the empirical data to be collected from various stakeholders. These decisions pushed the project toward more desk research

- and moved research funding toward top-down remote sensing products.
- The COE also spent a significant amount of time in this second stage engaging with various institutional stakeholders, many of which were part of the primary production industry. This was driven by a need to secure funding to ensure the sustainability of the COE, but also to create relationships with institutions and actors who could help critique the functional potential of multi-functional landscape redesign projects.



### Key Activities Undertaken by Different Teams During the Co-design Process

#### The Social Team

Despite the significant effects of COVID-19, both on the livelihoods of primary producers in Aotearoa NZ and the constraints it put on more intimate engagement with such stakeholders, the social team did manage to get some information

about the aspirations of regional farmers and industry actors. These are presented below.

*Farmer Opinions.* The COE team conducted semi-structured interviews with 7 people involved in the primary production industry from the South Island. Of the 7 there were five men and 2 women, and 2 were involved more in the industry with the supply

chains of primary production and 5 were primary producers who were farming sheep, beef, and dairy.

They were asked questions regarding,

- (1) Their current anxieties and aspirations?
- (2) Their future anxieties and aspirations?
- (3) What did they think about the COE and the work being attempted there?
- (4) Would they want to be a part of such work? Why or Why not?
- (5) Did they have any advice for us?

The anxieties and aspirations of the primary producers echo recent research into rurality and livelihoods in Aotearoa NZ (Figure 5) (Lewis et al., 2013; Rosin et al., 2017).

Their answers to work being done at COE and potential avenues for collaboration were heavily concentrated on incentives and the lack of capacity to engage. All 7 agreed that there needed to be more collaborative work across science-society, especially through initiatives that did not position the knowledge of the scientists as more important than the knowledge of the farmers.

### The Te ao Māori Team

*Māori Cultural Mapping.* The team working on Māori cultural mapping decided on three objectives to pursue through their work with the COE.

- To use Māori cultural mapping as a tool to re-imagine and re-design the landscape. To aid in this process they reached out to *Kā Huru Manu*, The Ngāi Tahu Cultural Mapping Project (<https://www.kahurumanu.co.nz/>) to procure existing cultural landscape visualizations, which would form the foundation of their mapping activities.
- To use the Mauriora Systems Framework (MSF) (Figure 6) both as a processual tool to ensure Māori knowledge sovereignty and as a conceptual tool to understand the present state of the mauri and how to ensure its well-being in the future under various landscape management scenarios.
- To accept that there is incredible demand on Māori *whanau*, *iwi*, and *hapu* to participate in decision making and knowledge production on such projects. Keeping this in mind, the formal opinions and time of the *kaitiaki* would be requested judiciously and the Māori team leader would informally engage with them regularly to inform them of the team's ongoing work and ask them for feedback.

### The Design Team

*Participatory Objective and Goal Setting.* The COE during Stage 2 of the Co-design also facilitated multiple workshops to engage different stakeholders in the process of critiquing and suggesting landscape management objectives for the re-design project. These opinions were focused on the pastoral production and ecological health aspects of the landscape.

We used a participatory weighting technique, inspired by participatory action research (Farr, 2018; Johansson and Abdi, 2020) which quantified stakeholder aspirations by gauging both their self-described prowess about a topic and the collective expertise of the group. The results are shown in Figure 7.

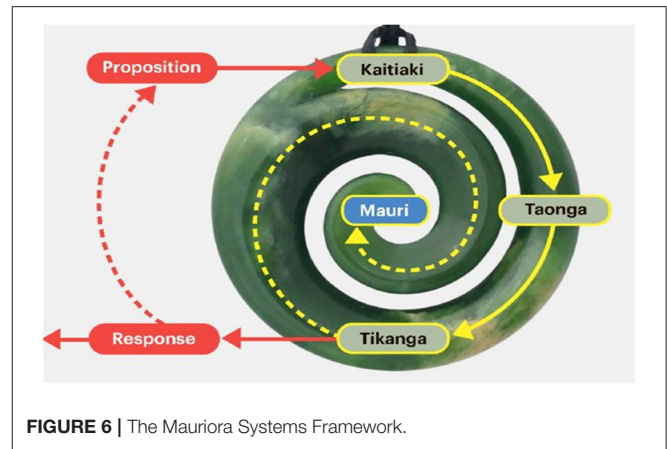


FIGURE 6 | The Mauriora Systems Framework.

Water quality, agroforestry, and pest management were identified as the three issues that were not being addressed by current practice which needed significant focus in any future re-design attempts. Interestingly while pasture-based production systems were being addressed in the current scenario the need to ensure their well-being in future landscape design was quite robust.

### The Pastoral Production and Landscape Health

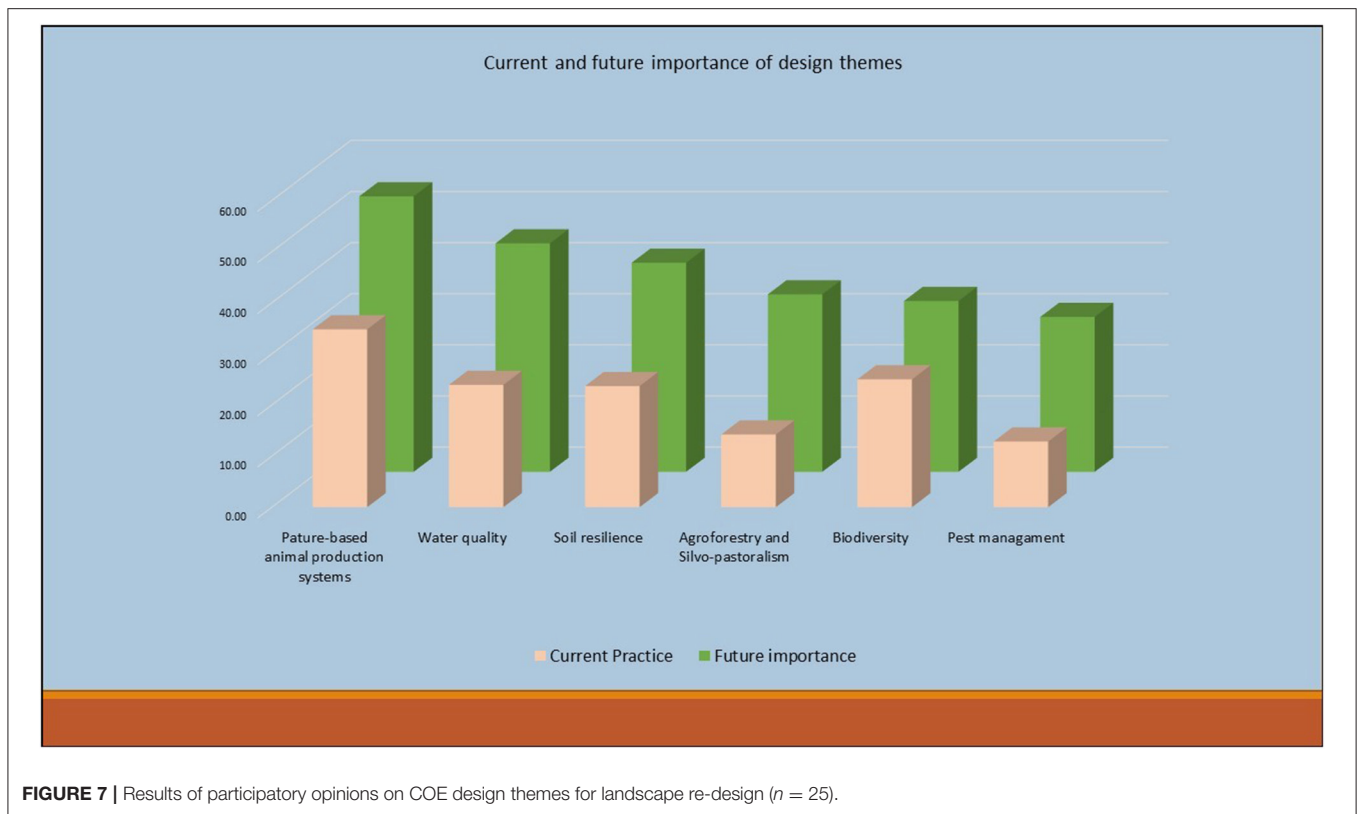
*Farm Scale Spatial Mapping.* The team identified existing farm-scale data from the national land use and land cover database which is used in conjunction with LIDAR data produced by data analytics company and field data gathered on-site at the farm to create capability and suitability maps using ArcGIS software (Figure 8).

### Overview of Co-design

- Co-design at the COE was a contentious and dynamic process with processual objectives changing based on discussions and engagement within the group. The salient features of the co-production process mentioned in Figure 1 did not emerge linearly at the beginning but instead were developed throughout the co-design process.
- The COE group spent the most amount of time discussing methods, while values and engagement were the least discussed (Figures 3, 4).
- The most synergy was seen between the design team and the pastoral team, while the most challenging exchanges happened between the design team and the *te ao Māori* and the social teams (Figures 3, 4).
- While the opinions of stakeholders from the primary production industry are quite insightful their engagement with the overall co-design process was quite minimal (Figures 5, 7).

## Knowledge Products From the Co-production Process

Knowledge co-production at the COE took the main stage starting in March 2020 and that process is ongoing. The co-production through the various teams and the COE given the capacity (technological and labor), skill sets, funding timelines,



**FIGURE 7** | Results of participatory opinions on COE design themes for landscape re-design ( $n = 25$ ).

institutional mandates, and long/short term goals led to a culture of co-production which is visualized in **Figure 9**.

From the figure above it can be surmised that the process of co-production echoes the synergies and challenges that emerged during the co-design process and contain both “strong” moments of co-production (MD, SD, MS) and “weak” moments of co-production (M, S, D). The most advanced knowledge products are the ones associated with Māori and Pastoral and Design. In the next few paragraphs, we summarize some of this work to present some tangible outcomes of the knowledge co-production process.

#### D: Farm Scale Master Planning

The farm-scale master planning was done using existing land use and land cover data, farm management plans of MT. Grand, site visits for ecological and hydrological mapping, remotely sensed products, and stakeholder insights that emerged from co-design workshops and participatory review of design goals and themes. It also considered the existing capability and suitability of the landscape’s production management and incorporated some of the insights from regional primary producers and industry actors. A tentative draft master plan is shown in **Figure 10**.

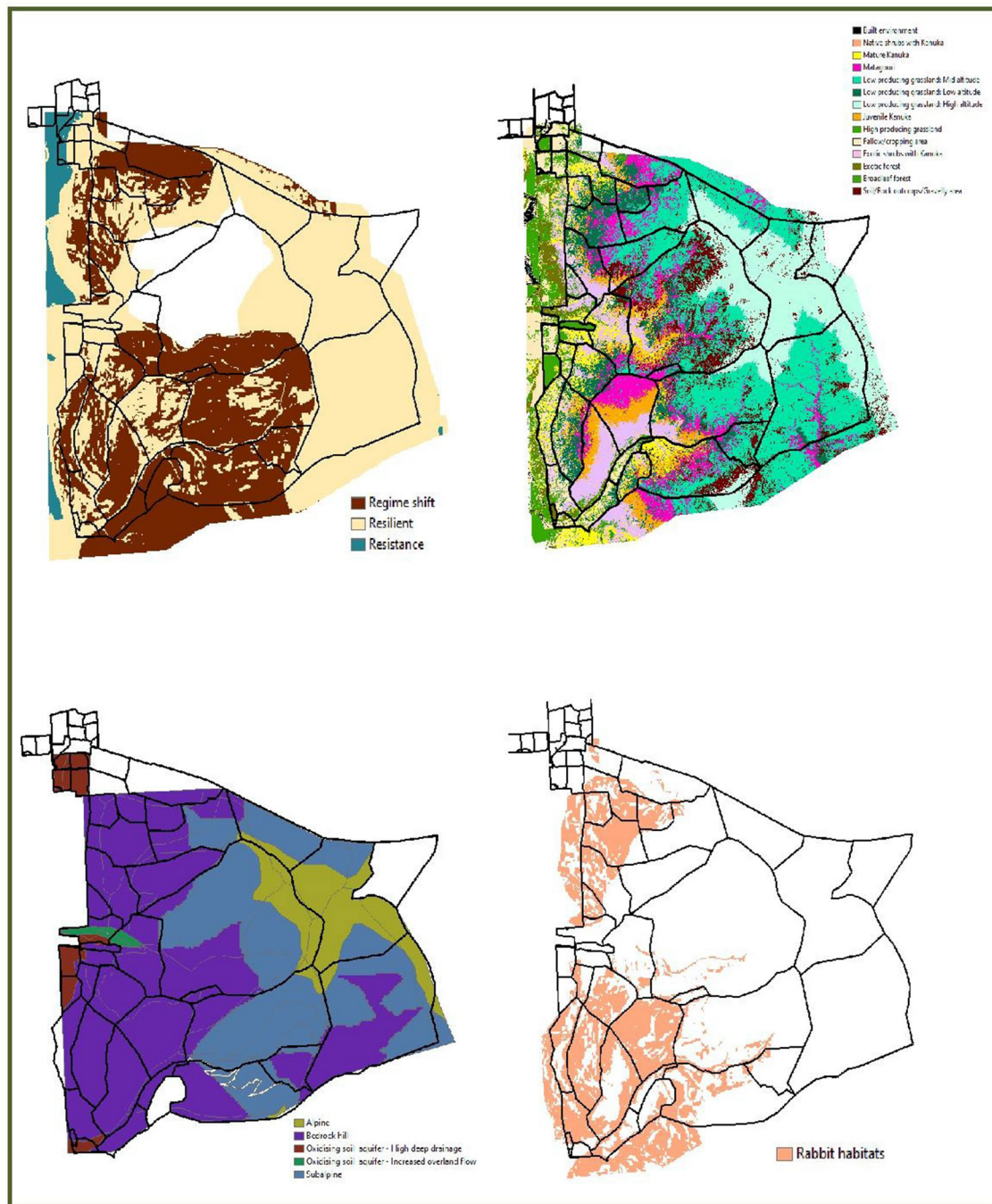
The plan as it currently stands focuses on regenerative silvopastoralism, soil resilience, hydrological management, and the creation of a carbon positive landscape. This plan is a result of collaborative efforts within the design and pastoral teams with complementary inputs from the social and Māori teams.

The tools highlighted in this knowledge product are GIS-based spatial analysis, landscape ecology design principles, and farm management planning and the scale of focus is the farm. In detail, the process entailed,

- Multi-objective ecological and production-related aspirations for the farm were obtained from managers and scientists. These included the capability of the land to support healthy pasture, soil management, and soil management, enriching riparian buffers, changing rabbit habitats, and improving biodiversity through Silvo-pastoral systems.
- Remote sensed data products, existing land cover maps, farm management plans, and regional zoning maps were brought together to situate the farm within a certain spatial context and to identify areas of special vulnerability.
- Paddock scale SWOT analysis of the complete station done by the various experts that are part of the center. This analysis took into consideration the disaggregated objectives of each major theme.
- A designer compiled all this information onto a visual platform.

#### M: Regional Scale Cultural Maps

Māori have been spatially articulating their relationship with all the islands that form Aotearoa NZ ever since they arrived (Hakopa, 2019). However, European colonization through its many violent manifestations has led to significant erasure of both place-based and more mobile renditions of Māori landscapes (Pawson and Brooking, 2013). The maps being produced by the



**FIGURE 8 |** Farm scale mapping of key pastoral and landscape health variables.

Māori team at the COE attempt to challenge this cartographic reality, but to also provide a more holistic visualization of human-land relationships which contain material (lakes, trees, houses) as well as non-material elements (stories, spirits, emotions).

An example of a map made by the team is given in **Figure 11**.

This map spatializes the cultural history of the landscapes within which Mt. Grand is situated and is intentionally

on a regional scale to include the vital stories of how the landscape features we see in that region came to be.

Rākaihautū’s story of digging the lakes of the South Island with his magical *ko* (digging stick) and filling them with food, including lake Wānaka which is next to Mt. Grand, is presented in this rendition. Along with that are stories about Aoraki

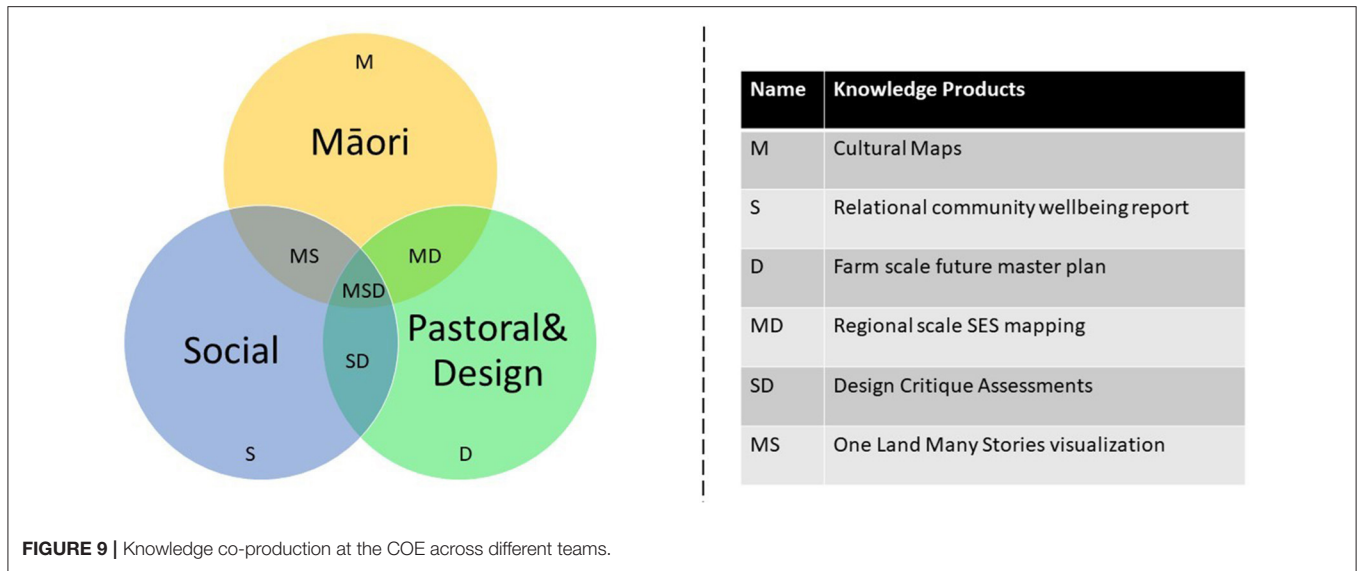


FIGURE 9 | Knowledge co-production at the COE across different teams.

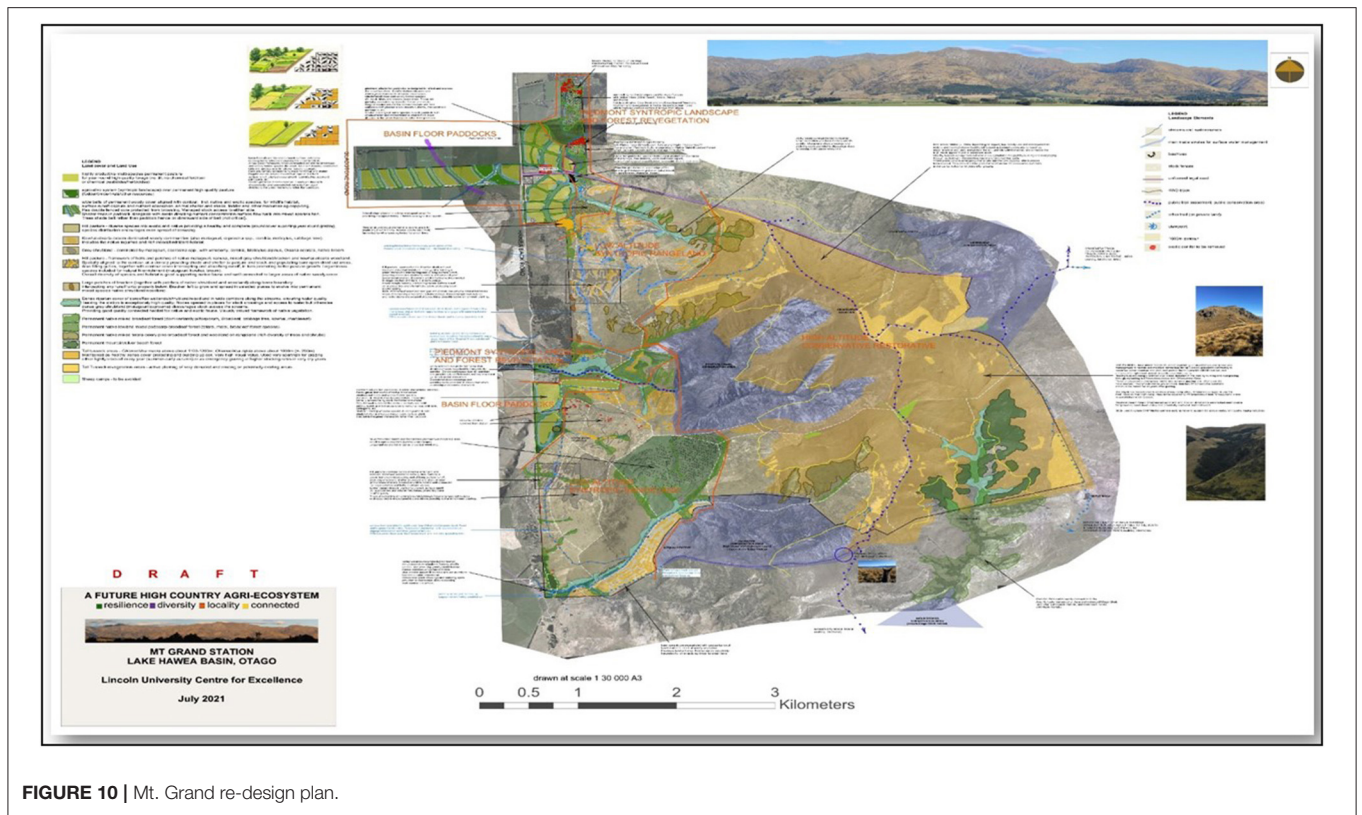


FIGURE 10 | Mt. Grand re-design plan.

(Aotearoa NZ’s highest mountain) and his brothers as well as the cultural history of the Mata-Au River. Finally, as *katiaki* of the regional district state,

“Our associations are much broader than discrete sites. An archaeological site will contain items, but we are talking about is the *korero* (conversation and dialogue) which goes with a place and that blankets a place like a *korowai* (cloak), overlays it, which does not have very strong boundaries”

The goal with this map is to move the COE’s focus out of the farm-scale and current and future thinking, into the regional cultural landscape and the past. Additionally, it is to present a landscape version that questions the different “boundaries” that are used in current landscape planning to characterize things like urban zoning, conservation habitats, sustainable food gathering sites, watersheds, and primary production zones. Finally, it also complements and supplements current notions of relationships

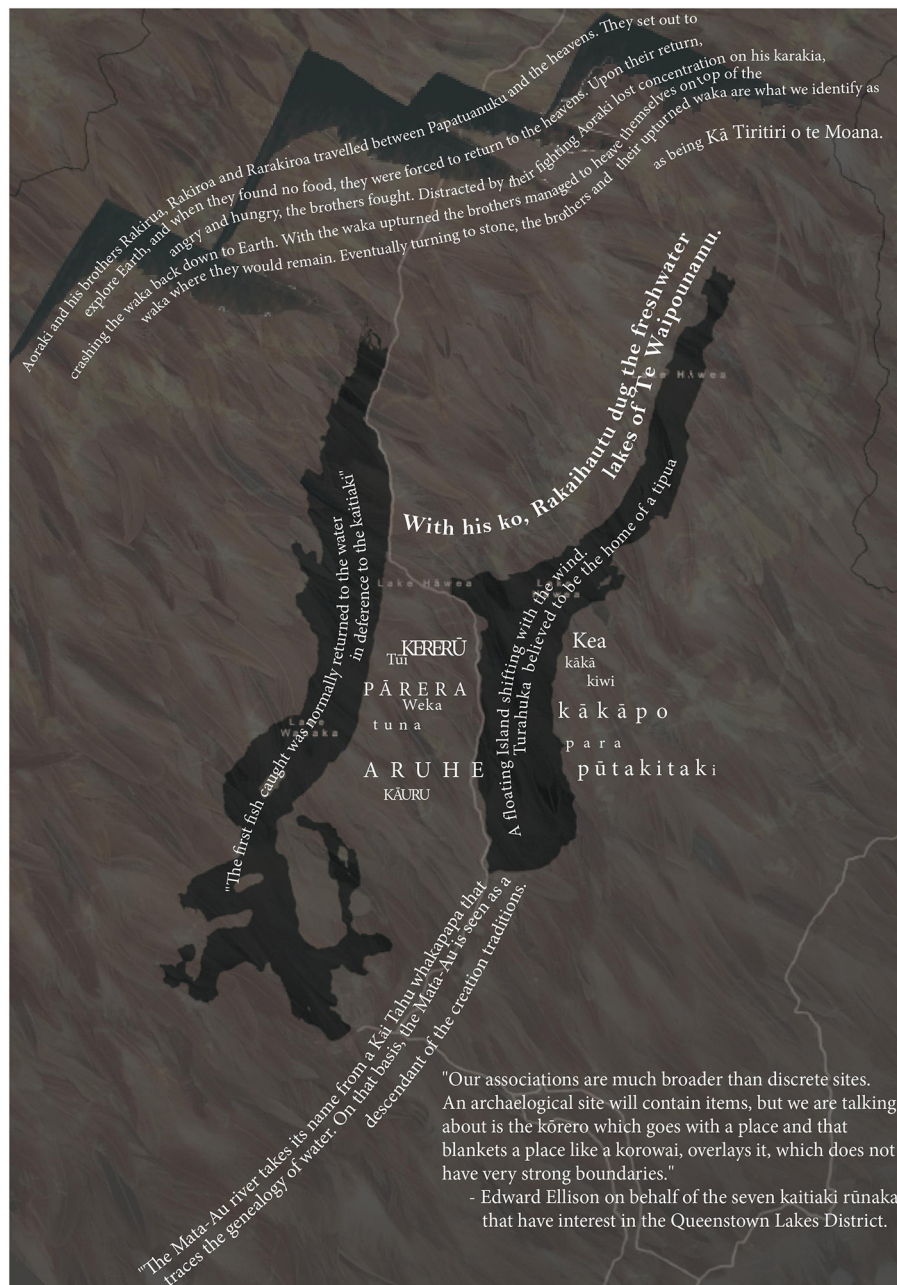
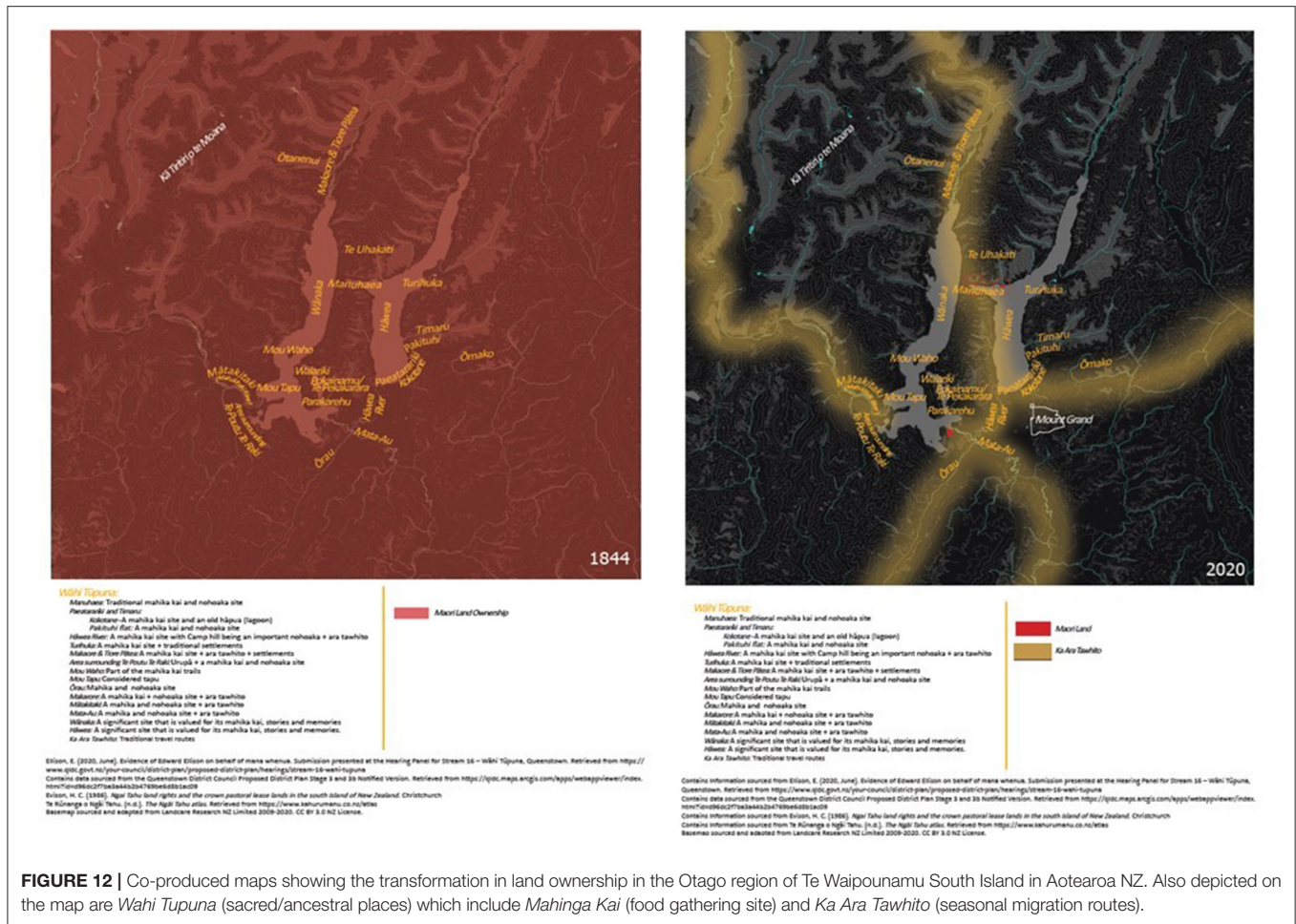


FIGURE 11 | A cultural map of the Mt. Grand region.

between various landscape forms such as rivers, mountains, farms, and cities.

The tools highlighted in this effort are indigenous cartography, visual storytelling, emotional and affective landscapes, and participatory mapping. In detail, the process entailed,

- Engaging with The Ngāi Tahu Cultural Mapping Project (<https://www.kahurumanu.co.nz/>) to get permission to use their cultural maps.
- Identifying vital points/processes of importance from various maps prepared by *iwi*, councils, and *Papatipu Runangas*. These maps also go back in time to highlight some of the historical changes in ownership and management.
- Co-design meetings about which stories to use, their significance for the landscape, and their role in exploring social-ecological well-being for the future.
- A Māori designer looked over the identified stories, existing landscape forms, and statements from the regional *iwi*, councils, and *Papatipu Runangas* and created the map.



**FIGURE 12 |** Co-produced maps showing the transformation in land ownership in the Otago region of Te Waipounamu South Island in Aotearoa NZ. Also depicted on the map are *Wahi Tupuna* (sacred/ancestral places) which include *Mahinga Kai* (food gathering site) and *Ka Ara Tawhito* (seasonal migration routes).

### MD: Regional Scale SES Mapping

Co-production of maps that attempt engagement across the constituent and Māori knowledge systems has been a very contentious and productive undertaking at the COE. During the co-design phase, there were significant challenges between the Māori team and the landscape design team, especially regarding the spatialization (and visualization) of immaterial objects, beings, and processes and the scalar biases of attempting landscape design from the perspective of existing land ownership and zoning laws. Despite significant divergences in the values, objectives, and goals of the project, the Māori and design team managed to collaborate on producing a few visualizations which attempt to include plural goals and tools.

A couple of examples are shown in **Figure 12**. The two maps were produced in collaboration with a Māori designer and a spatial analyst using data from historical narratives of Māori movement across the landscape and over time change in ownership of land in the south island from the Whenua Māori Visualization Tool developed by Te Puni Kokiri Ministry of Māori Development and Manaaki Whenua Landcare Research (<https://whenuaviz.landcareresearch.co.nz/>).

The *Ka Ara Tawhito* (seasonal migration routes highlighted in yellow) shown in (**Figure 12**) crisscross a vast landscape

from the mountains to the ocean and reveal the vast and dynamic territorial presence of the Māori. In doing so they challenge colonial notions of land use rooted that remain overwhelmingly rooted in more sedentary notions of communal infrastructure. Simultaneously they visualize, throughout more than 170 years, the changing control over the land, from Māori to the settler colony.

Visualizing these *Wahi tupunas* allows a different landscape to emerge and facilitates the process of cultural and political inclusion and ultimately, plurality. Concepts such as deed validated land ownership, productivist management, and intensive livestocking are challenged in this visualization. Additionally, due to protocols and procedures enshrined in the Treaty of Waitangi (Ataria et al., 2018), such revelations necessitate all landscape management programs to be co-developed in consultation with Māori stakeholders. Therefore, even though the current MT. Grand management plans fail to account for the significance of the migration routes, our visualization makes the case that it should. Additionally, they can also be used as “boundaries” for demarcating land, paralleling existing land demarcations that remain rooted in the notion of property ownership and sustainability equilibriums between production and conservation.



## DISCUSSION

In their review of co-production practice, Jagannathan et al. (2020) note that co-production practice is often hindered and fails to address the objectives of co-production theory due to existing power differences and the bounding of co-production projects by institutional and funding realities. The work done at the COE echoes this insight, especially when viewed from the perspective of more radical, long-term transformations in social-ecological relationships. Keeping this in mind, we return to the questions we began with and explore the major synergies and challenges that emerged during knowledge co-production. We argue that the COE's experiments with co-production reveal four important points.

First, designing, managing, and sustaining co-production should be pursued with a significant focus on the co-definition of values and objectives and require mitigation procedures in place to explore how different values can coexist within the co-design space. Our initial forays toward co-design were quite contentious with significant challenges when it came to defining how knowledge should be produced, who should it serve, and what the group should aspire for. The COE did not have the resources in place to mitigate these cleavages, and many contentious exchanges, especially those that were problematic from a Māori perspective were tabled at an impasse. This was especially problematic for the indigenous stakeholders who were burdened with not just continuously exposing their historical trauma but were also kept from forging truly innovative concepts in collaboration with the more mainstream views of sustainability. This is reflected in significant challenges that were recorded between the Māori and Design teams, but also in the fact that in stage 1 of Co-design the COE team as a whole did not spend enough time discussing the more essential “values” underpinning our work or exploring tools and techniques for “engagement” across the different disciplinary and ideological silos. Instead, as has been recorded in other co-production attempts, much of the conversation, even in the initial stages was around the appropriate methodology (Parsons et al., 2016; Sutherland et al., 2017; Turnhout et al., 2020).

Second, it is important to understand that co-production with multiple stakeholders should be aware of what that represents for different groups given both their current capacities and historical inclusion (or exclusion) within the process of knowledge production. Therefore, one of the moments of synergy in the COE was the acceptance that IPLC stakeholders had been part of multiple projects in the past and were also currently burdened by invitations from other such initiatives. This led the COE team to decide that the inclusion of multiple stakeholders would have to be contextual, especially when the institutional timeframes for the university and those of IPLC actors were very different. So, while the COE team embraced, what can be termed, “weak” co-production, limiting the inclusion of IPLC to a few key actors during the co-design phase, they were responding to IPLC stakeholders who expressed that they wanted a more “concrete” idea of what the COE was proposing before investing their time and energy. We believe, pursuing such active representation, can

address the problem with tokenism which co-production has struggled with (Reid and Rout, 2018; Zurba et al., 2021).

Third, COE remains more focussed on methods that lead to tangible knowledge products and less on evaluating such products for the realization of plurality, accountability, and engagement. As mentioned in **Figure 2** the salient features driving our work at the COE foreground these elements. However, finding synergistic evaluation tools for the work done by various teams has been quite problematic, especially since the assessment of the products must be inclusive. While scholars do mention certain pathways for addressing the evaluation problem, converting theory to practice has been marred by challenges to the viability of different metrics (Polk, 2015; Norström et al., 2020). For example, assessing the co-produced regional scale map led to questions about whether Māori stakeholders wanted a plurality of concepts and aspirations to define their visualization of the land, or whether they wanted their goals of sovereignty to be the final value being measured. This also raises a point made by Wyborn et al. (2019) that co-production does not always lead to “better outcomes.” However, in the case of the COE, due to the lack of assessment tools, we find it hard to agree or disagree with this proposition.

Finally, both synergies and challenges proved to be equally meaningful when pursuing co-production. The discussions that took place during the co-design meetings were incredibly useful in presenting very clearly the disciplinary silos and the different understandings of knowledge production that existed on campus. As many scholars have pointed out that there is a greater need to engage with the politics of knowledge production, and the discussion meetings, the participatory design theme setting, and the process of map-making brought this to the forefront. While the team at COE is still working on finding places of engagement across the different intra-group teams that were formed, there is a clarity in the objectives and values of different actors which did not exist at the beginning of the process.

We think the work done at the COE echoes two ongoing, unresolved problems in knowledge co-production.

First is the mismatch between more radical and socio-ecologically transformative ideological goals and the more pragmatically, functionally useful outcomes from the practice (Tengö et al., 2017; Jagannathan et al., 2020). We think this cleavage is sustained by the very different funding and institutional realities of academic, project-oriented knowledge production and the complicated, historical problems that require long-term, multi-spatial solutions. A great example is the differences between the farm-scale maps and the regional cultural maps. The farm-scale maps address the needs of a land focussed institution of higher learning that the COE is based on to provide innovative land management ideas which also respond to the insecurities of regional farmers. However, the cultural maps being produced by the COE address the latent issues of power within a settler-colonial society and how they manifest onto the land across a long period. Therefore, currently, the landscape is divided into multiple parcels, each of which depending on their ownership and use, are held accountable to different sets of ecological and social compliance, but this system of

relating to the land deviates considerably from pre-colonial Māori visions of stewardship and ownership. Lacking this time dimension, managing land ends up constrained by the myopic vision of a certain administrative reality and it can be argued, a very specific human/nature relationship. The maps highlight a process of place-making that challenges current visions of ownership, control, and democracy, which remain tied to specific visions of personal property and renditions of history that fail to capture Māori land use. The land dispossession caused by colonial capture of Aotearoa NZ is an unresolved issue, whose ongoing impacts are well-documented (McIntyre, 2007; Forster, 2016; Ojong, 2020). Thus, while our work through cultural mapping attempts to reveal the limitations of juridically ordained indigenous land rights in facilitating land and agro-pastoral management that is healthy and equitable, responding to a longer more transformative goal, our farm-scale map addresses the needs of the university to experiment with innovation which also respects the anxieties of regional farmers.

Second, building off the earlier point there is a lack of multi-scalar and multi-temporal knowledge production for multi-functional landscapes (Stürck and Verburg, 2017). While there is a bewildering diversity of knowledge available to land managers and policymakers (Maharjan et al., 2019; Paltsyn et al., 2019; Chaudhary et al., 2020). Presenting such knowledge in formats that appeal to a variety of stakeholders is critical to ensure both the sophistication and the democratic potential of land management. Additionally, the tools of exploration (satellites, field workers, farm system outputs), due to their scalar biases, are talking past each other rather than with each other. Ultimately, contingencies of capital, manpower, and time often limit research programs and policymakers to extrapolate their findings onto the relevant land unit. Our work addresses such issues by (1) holding different scales (farm, person, region, etc.) as non-constitutive, that is, the seemingly larger units are more than the sum of the smaller ones (2) by attempting to work on projects across as many unique scalar units as possible (3) By including time as a key component of scale, especially when co-producing knowledge with indigenous stakeholders.

Ultimately, the experiments with co-production at the COE while seemingly time-consuming (30 months) have begun to delve into the critical aspects of engagement—ensuring the disciplinary marriage we have been searching for, and inclusion—which given our current more tangible objectives would incentivize IPLC to come to the discussion table. And, this is when we need to focus on sustaining the co-production through building on the non-exploitative and non-extractive relationships that we have worked hard to establish between the various stakeholders.

## CONCLUSIONS AND THE WAY AHEAD

At the COE, with the goal of re-designing a farm to function as a multi-functional landscape, we attempted a process of knowledge co-production to ensure equitable representation of different stakeholders in a certain region of Aotearoa NZ. This process was documented through ethnographic participatory observations of

meetings and workshops and materialized through knowledge products that emerged from this collaboration. We did thematic and qualitative coding of these exchanges and explored whether the actual process of knowledge production addressed the salient features guiding the work. While our work led to some vital insights into co-production, especially in regards to co-designing for plurality and inclusion, which led to land visualizations at different scales and temporalities, significant work remains to be done to address both IPLC inclusion throughout the process and to create assessment frameworks that can adequately evaluate such co-production. We draw the following three lessons from our work.

First, the COE, and similar initiatives at knowledge co-production, while pursuing stakeholder inclusion need to facilitate more opportunities for various segments of the IPLC population to engage with the project. While in the past the COE was advised by representative stakeholders to hold off on such contact before constructing a more concrete set of objectives and some tangible examples, we are currently ready to collaborate and need to pursue this in the future.

Second, while the COE has been successful in creating some collaborative knowledge products, we have important shortcomings when it comes to evaluation metrics. Our future work needs to focus on experimenting with different assessment frameworks and we have already started engaging with existing options. This is especially important given the diversity of indicators and variables in multi-stakeholder, multi-functional landscapes, and is a significant data gap

Third, the mismatch between both scales of knowledge production as well as its ideological goals can be a significant roadblock to achieving successful co-production. Such mismatches can be addressed through long-term trust-building with IPLC communities, conducting multiple projects exploring similar objectives at different scales, and finally, pursuing research that has utility for IPLC aspirations that go beyond mere knowledge production.

We conclude with a call for more studies that assess the process of knowledge co-production especially with IPLC focussing on highly contentious topics such as land management and re-design, which foreground issues that stem from disciplinary bias, colonial erasure, and the marginalization of non-expert opinions. While it can be a very difficult task addressing questions of values, objectives, and inclusion, especially when there are glaring power inequalities across stakeholders, it can foster a culture of constantly reflecting on whether power is shared and how the practice of co-production needs to be actively gauged against the aspirations of co-production. As institutions and governments around the world mobilize to address the various crises stemming from land use, climate change, and unequal resource distribution, the care of landscapes has become a critical issue. Planning this care requires a direct engagement with the historical relationships between the various stakeholders and understanding how that manifests into producing knowledge to sustain such plans. Exploring this knowledge production and evaluating its viability through a prism of diversity and utility will be

essential in ensuring its success and can create truly inclusive multifunctional landscapes. We suggest that knowledge co-production attempts in multi-stakeholder landscape design and management should attempt similar assessments of their process to ensure the relevance of the research to the various stakeholders.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Lincoln University Human Ethics Committee. The

patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

RC did all the writing, human subject field work, and analysis of the knowledge co-production data. SJ produced the farm scale maps. HM and LM produced the Maori cultural maps. JE, SD, and PG provided editorial support. All authors contributed to the article and approved the submitted version.

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