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Healing Fragmentation of Forest Biosecurity Networks: A Conceptual and Reflexive Mapping Analysis of Postcolonial Relations that Matter in Aotearoa|New Zealand and Cymru|Wales

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ABSTRACT. Scientific biosecurity has become an important approach for managing the threats to Kauri trees and plant management in Aotearoa|New Zealand and Cymru|Wales, more generally. However, the conceptual apparatus of biosecurity does not make the relations and overlaps between people, knowledges or values visible in practice. This is

particularly so for Indigenous Māori knowledge and ontologies, which are not yet fully integrated into this field. This paper has two aims. The first is to understand how the fragmentation of the biosecurity system concerning plant pathogens is reproducing colonial relations, while shaping biosecurity practices in new ways. The second is to use postcoloniality theory as an analytic tool to understand the role that local and Indigenous knowledge and ontologies play in the biosecurity system more globally. This lens is specifically turned on the social scientific understandings of biosecurity and used to analyse the relationships of others involved in the generation and use of biosecurity science for the protection of trees in Aotearoa|New Zealand and Cymru|Wales, analysing through the lens of social science, our interviews, and focus groups with them. Two places and ways of understanding postcoloniality are deliberately evoked so that postcolonial *relations* become the dominant lens for understanding how society and the environment have become dis/entangled in the biosecurity system in various ways. Some consistent clusters of biosecurity fragmentation can be identified along with the emergence of specific social and environmental relations that underpin shared aspects of care with/for trees and ecosystem conservation. This result demonstrates the impact that fragmentation could have on building a relational structure and ethics of biosecurity, linking communities, geographies, policies and values. Our conclusions echo the range of questions and relations at stake resulting from this fragmentation of biosecurity and show the role(s) that social scientists and Pākehā scientists can have in opening spaces for new postcolonial biosecurity practices to emerge.

Keywords: postcolonial science; biosecurity epistemology; plant pathogens; Aotearoa|New Zealand; Cymru|Wales; social science

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Introduction

Biosecurity involves the practices of protecting valued assets from the threat of pests and diseases. It is informed by scientific research and governing commitments that are, in turn, shaped by cultural identities and worldviews about what is biologically important or in need of protection and what constitutes a threat. Over the past few decades, biosecurity science has fragmented and differentiated substantially through a widening variety of pathogens, new anthropogenic routes of transmission (from logging to rapid air travel), and environmental changes (climate change). Globally, this has given attention to the contestations surrounding the universality of biosecurity science and the problem of epistemological holism, where one set of values, i.e., those belonging to Western or normative 'mainstream' science, are held above others (Barber, 2022). Within the global domain, where biosecurity has circulated as a governance term and

concept, we find debates intensify about what constitutes a biosecurity threat (Clark, 2013). Equally, we find debates that link biosecurity to land use and land ownership and to colonial ways of thinking, which shape understandings of the social and political context for biosecurity protection and responsibilities (Black et al., 2019; Lambert & Mark-Shadbolt, 2021).

The fragmentation of biosecurity is not inevitable, although the debates are far from converging on the implications of colonialism. Dietz (2003) argues that we might take fragmentation as a sign of biosecurity sciences' 'vitality.' To make this argument, we bring into conversation the testimonies of scientists based in Aotearoa|New Zealand (henceforth, Aotearoa) and Cymru|Wales (henceforth, Wales) on inherited colonial ways of thinking and practices of biosecurity in both settings. Even as biosecurity leans towards collaborative and co-produced knowledge and investment in the environment, in this paper, we delve into the conundrum generated by colonial legacies in biosecurity and their manifestation in fragmented biosecurity systems and landscapes. We finally consider what this means for effective biosecurity action.

On fragmentation

Fragmentation is used in conservation biology as a spatial concept that describes an occurrence at a landscape scale that disrupts continuity and shapes the functioning of ecosystems. In conservation terms, fragmentation has biological and spatial attributes. As part of a matrix or collective, fragments can have significance, even if they are small. Fragmentation can occur geographically or structurally as previously intact areas can become fragmented through processes that modify and change environments, such as when invasive species cause habitat fragmentation (Lord & Norton, 1990). While fragmentation effects are experienced by ecological communities differently depending on their needs and responses to ecosystem change, there is evidence to show that the processes that shape fragmentation are interdependent, i.e., size/spatiality, time/temporality or perception (Manning et al., 2004).

While fragmentation is an important concept in the biological and conservation sciences (Didham, 2010), the term is used in social sciences in other ways to describe processes of theoretical and social change leading to disruptions in social action or institutions (Goodman, 2019). Klingebiel et al. (2016) define fragmentation as 'the phenomenon of a multiplication of actors and growing atomisation, affecting goals, modalities and instruments as well as numerous operational and non-operational activities' (p. 1). It may describe the effects of geographical and structural fragmentation, particularly on vulnerable communities, most often represented as a form of societal breakdown. Bocarejo et al. (2016), for example, show how a new transit system in Bogata, Colombia contributes to social fragmentation.

In both the ecological and social sciences, the idea of fragmentation has taken a positive turn. Several studies point to the benefits of fragmentation, either because

it allows for smaller units of people or places to seek cooperation (Biermann et al., 2020) or because it recognises the high conservation value of even small habitats (Fahrig et al., 2019). In part, a search for the positive effects of fragmentation occurs because fragmentation is considered prevalent and normative, and because most of its negative effects are due to decontextualisation and generalisation (Gehring et al., 2017). Generalising judgements about fragmentation may be misleading. Drawing on the current debate about the positive aspects of fragmentation, there is evidence that fragmentation may work positively in a development (aid) context because it provides choice (Klingebiel et al., 2016), and one of the main conclusions about minorities is that societal subgroups also come together in new ways following a departure from the strong cultural order, such as the LGBTQI+ community and other groups whose sense of identity is marginalised from mainstream culture. Accordingly, more emphasis needs to be given to ensuring the representation of diverse communities and perspectives in natural resource governance and supporting accompanying processes of social learning (e.g., McLoughlin et al., 2020; Medema et al., 2014).

This paper takes specific ideas about fragmentation from social theory, where fragmentation can be segmented, hierarchical, and functional, and integrates this with biological sciences' attention to structural fragmentation. Segmentary fragmentation is useful for analysing how biosecurity is performed in the different places of Aotearoa and Wales; stratification fragmentation analyses hierarchical relationships that may exist between institutions, for example, between scientific bodies and publics, while functional fragmentation allows us to assess divisions of labour in biosecurity, i.e., between affective and practical work. Structural fragmentation may exist in parallel across these forms of fragmentation and allows us to take account of how the biosecurity demands have changed in relation to the social or physical remodelling of the land. A consistent application of structural fragmentation is an analysis of the forced removal of Māori (collective) land ownership, which changed how communities could practically and productively use or manage lands (Reid et al., 2017).

On postcolonial thinking

How should we understand these struggles? Drawing on a global postcolonial analysis (Elwood et al., 2017; Ghosh, 2021; Halvorsen, 2019; Stewart, 2020), two points are important here. The first is the way in which colonialism separates culture from science and nature (initially by excluding all forms of Indigenous knowledge) (Stewart, 2020), and the second is the ways in which it 'retools' these relationships. The first point refers to the extreme specialisation and compartmentalisation of our modern science and ecological organisations, which are reflected in how the management and scientific objectives of forest managers focus on common ecological goals. Through assigning 'clear and distinct borders between the centre and the periphery,' colonialism has negated the role of knowledges, histories and cultures outside the periphery. The example given in

Aotearoa is reflected in land and resource struggles globally. Postcolonial analyses in India and Latin America have produced narratives of resource exploitation and violence against Indigenous communities that have long-lasting and catastrophic effects on both the natures and cultures of those communities (Ghosh, 2021; Shiva, 2016).

The second important thing is that a qualitatively new form of colonialism is emerging. Political ecologists have specifically condemned this new type of (green) colonialism (Loftus, 2019). Indigenous knowledge is now central to government agencies at different levels (e.g., IPBES) with the adoption of Indigenous concepts, technologies or practices, but there is an absence of Indigenous peoples in the design and implementation of policies. While a holistic ecological perspective is seen to be critical to adaptive management programmes for tree health, i.e., where the management approach is shaped by multiple perspectives (Bradshaw et al., 2020), de-colonialism is not a simple addition to existing approaches. In Ostrom's terms (2004; 2009), efforts to adjust or mitigate elements of the existing system requires the identification of a complex of social and ecological processes that could support effective change, but it is also a requirement that the entire system itself is systematically altered (Baker et al., 2022). Notably, while adaptive management seeks to change how science systems operate, efforts to join up diverse perspectives and incorporate the uncertainties and messiness of fragmentation, fragmentation can also stymie its capabilities to do this effectively (Hurlbert & Gupta, 2016; Muru-Lanning, 2020).

In postcolonial thinking, colonialism shares these characteristics, and addressing these challenges is at the heart of environmental and societal responses to climate change and resource exhaustion (McEwan, 2021; Watts & Peluso, 2014). Gago (2017) notes that while global capitalism is a shared mode of colonialism involved in the taking of land and the extraction of resources, the long and deep systemic processes through which capitalism has shaped each place have become invisible through what Nixon (2017) refers to as 'slow violence.' Here, historical time is enfolded into the current moment and makes invisible and fragments the specific forms of exclusion and extraction experienced over time and in each context.

Thus, Latin American theorist Mezzadra urges a 'postcolonial view,' referring to the 'divergences and hierarchies between places, regions and continents, [that] allows for understanding of the heterogeneous fabric of colonialism[, namely,] its regimes, temporalities and subjectivities' (Gago, 2017, p. 76). By emphasising the specific struggles against hierarchies that legitimate and perpetuate the exclusion of Indigenous access to land and resources in each place, Mohanram (1999) opens out a heterogeneous colonialism linked through land and capitalism, and the diverse experiences of Indigenous peoples. Appadurai (1988), along with Nancy Fraser too, notes that colonialism is not rooted in particular places and argues that efforts and obligations towards justice in the domestic space need to re-address forces of sovereignty and land that existed in a global context. For these thinkers,

colonialism must be assessed through more than one place to show how colonialism emerges and shapes thinking at the current time.

Colonial specificity and land/trees in Aotearoa (New Zealand) and Cymru (Wales)

Colonialism can be defined as 'a way to describe relationships characterised by conquest and genocide that grant colonialist and settlers ongoing state access to land and resources that contradictorily provide the material and spiritual sustenance of Indigenous societies on the one hand, and the foundation of colonial, state-formation, settlement and capitalist development on the other' (Liboiron, 2017, p. 9). Colonialism, therefore, is about land and about social justice. As defined by Liboiron (2017), colonisation shapes the intent, identities, heritages and economic development of land and belongs to ongoing processes of land relations that affect how resources are managed as an environmental, as well as a cultural, social and economic resource. Following this, a postcolonial analysis of biosecurity cannot ignore land, although, as mentioned, some scholars attend to how it shapes the specific discourses and materialities of place.

To avoid glossing over our point about the specificity of colonial processes, Aotearoa is famous for its natural resources and beauty, less so for how the ongoing health of these natural resources is deeply enmeshed in complexities of land ownership and colonial Empire building that was supposed to – in due time – put within reach of Māori[1] the benefits of proposed progress and economic prosperity. Jackson (1992) wrote that the history of Māori colonisation 'is a story of the imposition of a philosophical construct as much as it is a tale of economic and military oppression' (p. 2).

Take the case of forest cover in Aotearoa, which has been declining since the first human arrival, with a significant speeding up since the arrival of Captain Cook in 1769 (McWethy et al., 2010).[2] Where Aotearoa was 80% forested at that time, only 24% of land now is native forest (Department of Conservation, 2022). Thirty per cent of all land is managed by the Department of Conservation (Department of Conservation, 2022), and only 6% is considered Māori land. Preservation of the health of the forests largely remains under the management processes of the Department of Conservation and other scientific advisors, normally located in Universities and Research Institutions. This organising of management has shaped not only governance but also knowledge, not least by privileging western scientific understandings about native, culturally and economically important trees in Aotearoa. So that when the remaining remnants of kauri forests in Aotearoa (reduced to <1% after 200 years of destruction and exploitation) became threatened by kauri dieback ('a lethal root rot disease' caused by one of the *Phytophthora* pathogens), the disease's recognition, confirmation and surveillance was organised under a national Kauri Dieback Programme in 2009.

Another way to map out colonisation in Aotearoa is to understand the after-effects of the extensive logging of kauri, with land then used for agriculture, pine

plantations and recreation.[3] The land use changes have reduced and broken up forests, altered soil and ecosystem composition, contributed to climate change, and made kauri particularly vulnerable to pathogen spread (Young & Mitchell, 1994).

The fragmentation of forests has brought people and their introduced animals (pigs, dogs) closer to kauri, and their mobility and access mean that they can easily move between affected areas with the possibility of transferring the soil in which the pathogen resides. Tree health management has remained sites of systematic making and remaking of relationships (between peoples and between people and plants) that are linked to ongoing processes of colonisation (Watts & Peluso, 2014; Lambert et al., 2018).

Wales does not loom large in the colonial histories that have been written about the making of New Zealand. Today the most obvious physical manifestation of the relationship between Wales/Cymru and New Zealand/Aotearoa is the accounts of its British colonisers. But the transfer of wealth and power from Britain was dependent in part on the ability of Britain to represent itself as a coherent nation-state, where Wales took its place within the general processes that facilitated the colonisation of New Zealand. However, this obscures the patterns of activities and localised effects of colonisation occurring within Britain and the British Isles. Using again the example of forestry, rapid deforestation of Wales has occurred through the many phases of its own settlement, with woodland covering just 14% of the current land surface in Wales (in comparison to a European average of 37%) (Wong et al., 2015). The dependence of England on Wales for its natural resources (wood, coal, iron, steel), used for imperialist expansion, means that Wales can be considered the first British colony,[4] while simultaneously contributing to the ongoing process of British imperialism.[5] The distribution of resources from Wales has ensured a process of ongoing economic and social connections with Aotearoa, but the post-industrial breakdown of communities in Wales and its distinctiveness as a devolved nation means that Wales retains many aspects of its separate but economically poorer status from England. Examples of pre- and post-devolution include the imposed creation of timber forests to supply the forestry industry and the flooding of villages to create dams to supply these resources for England, often without consultation and perpetuating existing injustices through the 'othering' of local value (Milbourne & Mason, 2017). While more recently, forest and woodland management and legislation are handled separately under Natural Resources Wales, a Welsh Government body, Wales's land and environment remain inextricably bound to the wider history of Britain in a way that is 'fragmentated and parochial' (Evans, 2002).

Biosecurity as colonialism

In the case of biosecurity, the spread of mobile tree pathogens and threats to tree health are perpetuated by manifestations of colonialism. Since the development of biosecurity sciences, when the term was first used in agriculture and environmental communities to describe the preventative measures against threats from diseases

and pests, introduced and naturally occurring, the concept and use of biosecurity have expanded. Aotearoa was the first adopter of a comprehensive biosecurity approach (Biosecurity Act, 1993). The UK was later adopting a Britain-wide strategy (DEFRA, 2018; DEFRA, 2021). Significant outbreaks of disease (foot and mouth, ash dieback) were recognised as threatening agriculture, farming and silviculture.

While colonialism has been addressed in social theory and in science and technology studies, biosecurity science has rarely addressed colonial biases in approach. Biosecurity science emerged to protect the development of tradable commodities; here, science could be seen to economically benefit colonising communities that had access to land and resources rather than Indigenous communities. Yet, despite the closer sharing of knowledge amongst colonial scientists and Indigenous communities when Europeans were initially settling in Aotearoa, since that time, Indigenous rights and cultural practices relating to land management and knowledge systems have been eroded.

Other ways in which biosecurity has become infused with colonialism are shown in the assumptions and premises underpinned by risks to traded commodities. These assume that biosecurity can (and should) be applied universally, despite biosecurity referring to a wider set of threats that emerge from the failure to take human-nonhuman relationships seriously, and the existential threat that the loss of tree/forest health has for communities and society (Haraway, 2016). Nature reminds us, too, that threats are often multiple and dispersed over long distances through the movement of plants or plant materials, with spread accelerated by the establishment of timber plantations and the global increase in plants and plant-product exports. Thus, the biological dimension of the threat becomes further complicated by its close relationship to colonial practices.

The need to address diverse and dispersed biosecurity threats and colonialism (in the form of land and resource extraction) has appeared with increased frequency across research on biosecurity. The shared challenge of biosecurity in places that endure colonial legacies was significantly highlighted under COVID-19. This is where the aims of this paper sit. To assess the biosecurity science worldview considering colonial practices amidst biosecurity systems and to understand the role that fragmentation plays in biosecurity as it too becomes more specific to places and peoples.

Methodology

While there are many examples of how colonialism is enacted on identities, heritage and knowledge, Haraway's (2004) 'linking practices' (p. 138) allows us to bring into conversation the testimonies of scientists based in Aotearoa and Wales on inherited colonial ways of thinking and practices that permeate the biosecurity systems in both settings. Here, colonisation is not a fixed or deterministic concept. It is relational, contextual and consequential, and, as such, may offer opportunities

for alliances that pay attention to new opportunities for embedding postcolonial thinking in biosecurity practices.

Our two contexts in Aotearoa and Wales were clearly different with regard to colonisation and in relation to the plant pathogens being considered. In Aotearoa, the focus was on kauri dieback and myrtle rust (Soewarto et al., 2019), while different pathogens and pests are impacting tree health in Wales, including Ash dieback *Hymenoscyphus fraxineus* and *Phytophthora ramorum.* The data collection, analysis, and mapping were managed as complimentary, not contrasting, with insights shared from one context to the other.

Drawing on the experiences of those working with plant pathogens impacting the environment (te taiao), forests (ngāhere) and treasured (taonga) or valued species, we invited participants in a variety of (paid and voluntary) roles in biosecurity, biodiversity, science, advocacy, regulatory and operational work related to i) tree diseases (kauri dieback and myrtle rust) in Aotearoa (n=38) and ii) plant health or biosecurity of treescapes in Wales (n=13) to participate in interviews or questionnaires and workshop discussions respectively, see table below. We asked questions in a series of workshops in Wales and interviews in Aotearoa about biosecurity for trees. Ethical guidance and approval were elicited in each place, which in Aotearoa also included a specific response to treaty obligations under Te Tiriti o Waitangi.

Working across Aotearoa and Wales, questions were modified too so that they were relevant to treescapes and values in each context. Questions posed through the interviews and questionnaires by the research team in Aotearoa were about i) practices of care for, with and about taonga, ngahere and te taiao (treasures, forests and environments), ii) barriers to and facilitators of care and care practices, and iii) perspectives on what pathogens were teaching us. In Wales, participants in the focus groups collectively explored the relationships between treescape expansion, biosecurity and values with discussions framed around i) tree health and biosecurity and ii) communities and treescape creation and iii) perspectives on what pathogens were teaching us.

The process of our research was one based on activities familiar to those engaged in action research (see Fig. 1 below for a representation). The first phase is collaborative planning and action. In this phase, we reflected on our own relationships as a social science team.

Figure 1
Four phases of action research following a learning cycle

Note. Diagram depicting the cycle this research followed.

The second phase is data gathering and observation. In this phase, we connected with people in Aotearoa (interviews and questionnaire) and Wales (workshop) involved in tree biosecurity and tree care in a variety of ways through research, policy and practice. Separate research teams conducted the work in each place (AG, AG, SF-S, MA, WA, KS-E in Aotearoa and LO'B and SM-S in Wales). During this second phase of research, ten respondents completed a questionnaire, and 12 participants were interviewed in Aotearoa. Nine people participated in the Wales workshop. Thus, we had a total of 31 participants in phase two (Table 1).

The third action research phase is analysis, evaluation and reconceptualisation. Here we conducted a thematic analysis of our discussions and on the data collected through individual and group interviews.

The fourth and final phase is the testing of ideas. In this phase, initial findings were shared with participants and others from their teams to seek their feedback and reflections (co-analysis). During this second round of interviews and workshops, we shared insights for ethical co-design of biosecurity research, policy and practice between Aotearoa and Wales with the aim of furthering inclusive and diverse conversations around biosecurity, colonisation and possibilities for tree health management. We conducted small group discussions (2–4 people) with interview participants from phase one as well as some of their colleagues. These small group discussions added another 11 participants (five had already

participated in phase one) in Aotearoa. In Wales, an additional interview and a small group workshop discussion with 4 participants were conducted for phase four. With the additional 15 participants in phase four (Table 6), our total number of participants was brought to 46.

Table 1

Phase two: Data collection via an online questionnaire, interviews and workshop

Method	**Number of participants (n=31)**	**Participant roles**	**Location**
Online questionnaire	10	managers, advocates, volunteers, community operations	Aotearoa
Care interviews	7	researchers, managers, kairangahau (Māori researchers)	Aotearoa
'Experts with Experience' interviews	5	researchers, managers, community advocacy	Aotearoa
Workshop	9	researchers, policymakers, managers	Wales

Note. Table showing various methods and associated numbers of participants, participant roles, and locations for phase two. N.B. An additional set of interviews was conducted with people who were active in getting kauri dieback onto the political agenda (as requested by a PhD student working on our project).

Table 2
Phase three: Testing ideas through co-analysis sessions as small group interviews

Participating groups	Number of participants (n=20)	Participant roles	Location
Local Council	3	Policy, manager, researcher	Aotearoa
Research group 1	3	researcher (3)	Aotearoa
Research group 2	4	researcher (3), kairangahau	Aotearoa
Research group 3	2	researcher, kairangahau	Aotearoa
Research group 4	4	researcher (3), manager	Aotearoa
Policy-research interface	4	researcher (2), manager, policy	Wales

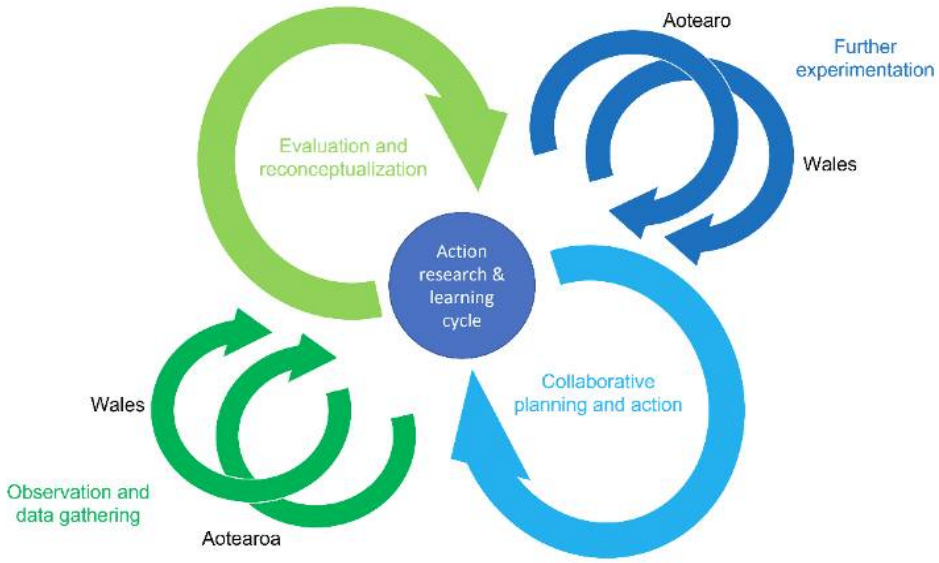
Note. Table showing various participant groups, numbers, roles, and locations for phase three.

Interviews and workshops were held online due to the COVID-19 pandemic and were recorded and transcribed with the informed consent of the participants. Social Ethics approval was received from both Cardiff University (SREC/4107) and Manaaki Whenua – Landcare Research (2021/24 NK).

Sharing conversations between Aotearoa and Wales enabled our joint reflections about colonisation, biosecurity science and practice, and treescapes or tree planting initiatives being taken in response to climate change and deforestation.

Our team of researchers across the Wales and Aotearoa contexts worked independently in data collection and came together as a team to discuss thematic aspects of the qualitative data collected (Fig 2) using Nvivo and direct coding of transcripts. Different approaches were used by team members, e.g., focus on narrative and effect, values and power relations, knowledge and actions, yet we examined emergent themes collectively and discussed areas of relevance and difference between the two contexts. Through this work, we began to identify a number of dimensions of collective practice that we thought would support those within the biosecurity system to work in more inclusive, respectful, pluralistic, and relational ways. Fig 2 shows how we worked through a parallel process of data collection and further experimentation in the Aotearoa and Wales contexts, coming together for phases of planning and analysis.

Figure 2
Parallel process of research in Wales and Aotearoa



Note. Diagram depicting the parallel processes of research in Wales and Aotearoa shown through two of the four phases. Copyright 2023 by the authors.

The process of action research is ongoing, and the project is now in its second cycle. The new phase one is developing a practice tool (rubric) and related theory around the emergence of postcolonial biosecurity possibilities using ethical guidance to identify what helps and hinders the development of shared and relational values. The rubric is a tool (being both a process and a product) to support biosecurity research and operational teams and partnerships who wish to improve their performance around the execution of these different practice dimensions. Planning is in place for envisaging and preparing for a workshop (linking Aotearoa and Wales contexts) on imagining biosecurity futures (cycle two, phase one). As action research allows for multiple and overlapping processes, this workshop will also be part of developing ethical guidance and a rubric for tree protection in collaboration with our Māori (and non-Māori) research colleagues

In this paper, we focus on aspects of analyses that link the Welsh and Aotearoa settings to support the understanding of the fragmentation of biosecurity with respect to colonisation and what postcolonial theory can offer future development of biosecurity in both contexts.

Findings

In the analysis of the interviews and focus groups in Aotearoa and Wales, we reviewed accounts of fragmentation in the context of biosecurity practices,

meanings and processes and asked two questions: What practices of biosecurity are fragmented, and how is colonialism linked to fragmentation? Three key themes emerged: the fragmentation of knowledge (visions, concepts and frameworks), the fragmentation of governance and management, and the fragmentation of places (communities and trees). These themes will be discussed below and illustrated with direct quotes from participants.

Fragmentation of knowledge

In mainstream science, the emphasis on a holistic approach means that it is concerned with complex systems. Biosecurity was discussed as a complex system in terms of how biosecurity science understands and responds to tree health threats, but also how science is part of a wider societal response to environmental problems. Engagement with communities and integration of the social and political dimensions are part of this wider societal response to biosecurity. In part, they reflect a wider tendency towards ecological holism, which encapsulates a distinctive shift from focusing on individual elements to the health of the ecosystem as a whole (Berkes & Berkes, 2009; Wilcox & Steele, 2020).

> Biosecurity [is] a discussion about provenance, silviculture and resilience, and silviculture systems…. (UK focus group)

Fragmentation emerges in the politics and structures of the biosecurity science system while also being an ecological problem. The participant above goes on to explain how efforts to talk about resilience are impossible because there is no one else in their team to discuss this with. As Bunge (2000) has argued, even social scientists accept these politics when they acknowledge that individual specialisms in science are constrained and/or stimulated by their relations to other science disciplines. As the participants identified, the defining feature of ecology as a holistic science is not the existence of individual disciplines but the bringing together of these disciplines in biosecurity science as a social endeavour, often leading to debates over power and authority, and issues with resourcing.

> That's how science is done. We do have a holistic science. It's called ecology … the specialist expertise all feed into that … So we need an entomologist … a mycologist … a biographer … a plantologist and … a plant pathologist. We have an issue right now where people [are] starting to throw up their hands and saying, this is too much. (NZ interview)

In thinking holistically, it should be possible to think of a common research and biosecurity goal but also of divisions and conflicts that emerge from the distribution of scarce resources. The participants identify, in general terms, the resourcing made scarce by colonial processes where the effort required to build and sustain cooperative relationships is considered additional to science practice, and yet where involvement is dependent on the resourcing of relationships.

> It's not realistic that hapū and Iwi are not resourced themselves to have [the] relationships … needed to support co-design and research taking place…. There has to be some middle ground where organisations form the relationships. I don't see any other way … to work. (NZ interview)

Part of the challenge for biosecurity is the question of how to involve multiple ways of knowing without the risk of fragmentation. This is not an easy task. Māori scholars have called for an approach that privileges and honours Māori intellectual systems involving tree health and plant pathogens. Such approaches can be aligned with more-than-human thinking, which also cautions against replicating existing ways of thinking:

> We were thinking about methods for trying to represent … well, how nature can have a say in what happens to it. […] So I do think, if you're thinking about Kauri forests, for example, that they should have a say in what happens to them. (NZ interview)

The approach used in Aotearoa (and in other Indigenous knowledge systems, see Goodchild, 2021) is one of bringing Māori knowledge systems and mainstream knowledge systems side-by-side (Macfarlane & Macfarlane, 2019; Scott et al., 2019). This approach is not focused on fragmentation but rather seeks to avoid or manage the threat of knowledge domination and assimilation. As Vaeau & Trundle (2020) write, this (not so simple) process is about 'valuing different types of knowledge, by understanding it as equally complex and robust as mainstream academic practices' (p. 212). In our discussions, there are some indications that attempts to work with parallel knowledges is having limited success but that biosecurity science is largely discussed separately from other knowledge systems, including non-human and Indigenous ways of knowing. Here, the need to prepare [students] for the international science community, the valuing of academic publications, their grasp of technology and scientific methods, the focus on a knowledge economy, competition between research institutions, and the politics of co-design, mātauranga Māori, and te reo were shared as part of the core (neoliberal) politics of science, with learning about and building capacity in mātauranga Maori proposed as the responsibility of individuals rather than organisations. Yet, deep-seated alignments to science significantly shaped the uneven distribution of knowledges and efforts to develop new ways of integrating diverse knowledge:

> You need to make that data publicly available for other scientists to use in a non-commercial manner…. Public money has gone into this…. This is a program deliverable…. This is a clash of two worlds problem. (UK focus group)

> Nobody trusts anyone because it's competitive. You have an advantage if you're sitting in a pile of data. (NZ interview)

> Nobody is going to care about their co-design…. [T] hey're going to care about the papers that they published and their grasp of their technology and their scientific method. (NZ interview)

This fragmentation of biosecurity goals and outputs, along with ideas about how it should be studied, ordered and organised, is framed by a perceived need for cohesiveness and robustness in the science system. Yet the way respondents experience biosecurity sciences and express themselves in it is tied directly to their identity (Stets et al., 2017). Māori scientists tell us something different about the fragmentation of structures, functions and the stratified nature of biosecurity, emphasising the barriers, the involvement of the state (government, 'Crown,' treaty settlement) and the slow timeline of change in the decolonisation of biosecurity sciences.

> Young [iwi members or mana whenua] all of whom … have come into adulthood since *treaty settlement* ... about a *decade ago* now…. The mind shift in them is really palpable…. They are unconstrained by a view that the *Crown* has any business in, uh, um…. It hasn't got inside their heads. T[hey] think, 'What can I do as [an iwi member or mana whenua]?' They are not looking for where are the *barriers* that government puts up…. It's not as though they're not going to encounter those barriers, but they're unconstrained by that as a first thought. (NZ interview, emphasis added)

The narrative above is also somewhat compelling for what a parallel view to the narratives presented earlier could look like. Starting from a different place means potentially not getting lost in colonial politics. Yet other examples of taking a holistic view (below) for ecological and decolonial reasons describe institutional structures that were slow and did not easily facilitate alternative practices,

> We wanted to take a holistic view…. That's pretty common, especially from an ecology standpoint…. What happened? […] [T]he process that we were stuck with … the institutional structures…. We wanted to engage really heavily with the relevant hapū, but … we were given such a short timeframe … when we're trying to do something different. (NZ interview)

In attempting to understand colonialism in biosecurity science, the theory predicts that efforts towards holism should align with the inclusion of multiple voices and knowledges. Yet, in practice, scientific power, a division of labour between scientific and relationship management, and a lack of consensus about how colonialism may be addressed were identified. We are left with a paradox in the fragmentation of knowledge, where fragmentation is part of the solution to the colonialism of science, as well as a consequence of it. As the implications of this paradox differ for different groups, the analysis turns to the question of governance

and how responsibility for re-assessing inequalities in the distribution of knowledge might be allocated.

Fragmentation of governance and management

The fragmentation of biosecurity knowledge has a clear effect on the fragmentation of governance processes that support the management of tree diseases (Coutinho et al., 1998; Miller, 2019). Understanding that there are multiple types of threats to trees and multiple responses to the fragmentation of knowledge helps us to grasp the complexity of the myriad of organisations, approaches, and values that might be involved in their protection, from national to local level.

> I would like to have a go at the fragmentation. For me, as a scientist, it's very difficult. [...] Even though I believe in a holistic approach, to get the money to do research, you've got to be really focused ... This is changing … at least you can see the bits of science that come together. (UK focus group)

> There is a lot of unused potential because we're not sort of joining forces … would be helpful to develop stronger movements…. [W]e're still working in silos and … neglecting or not appreciating enough what is done at that sort of grassroot level. (UK focus group)

Yet, the fragmentation of governance and management does not describe a breakdown of organisational structures that support biosecurity. Rather, it tells us something about what governance of biosecurity is intended to do. Biermann et al. (2020) refer to this as the quality of biosecurity. In the quote below, there is a desire to have a common protocol or approach to biosecurity, yet different organisations perceive and respond to the environment in different ways. The application of a common protocol arguably requires further oversight or governance in the form of leadership that values these different forms of knowledge. The implications of poor leadership are discussed:

> You've got DOC who are off already doing their own thing … for the conservation estate. You've got the council saying, 'We want to go off and do our own thing.' All of these parties are saying independently. […] [W]ouldn't it be great if we could work out a common protocol and share information. What are you going to do if they don't agree? Because they probably won't, and there's no leadership. (NZ interview)

Seeing the biosecurity system as fragmented is, therefore, not to assume that it has a pre-existing cohesiveness or that a shared approach is desirable, although leadership may be sufficient to manage conflicts between different groups in the pursuit of a holistic ideal (Biermann et al., 2020). The fragmentation of biosecurity governance is an understanding of the degree of overlap between organisations that have sometimes conflicting sets of approaches. However, the capacity for overlap

or difference is also about the organisational capacity to address the governance problem. In the quote below, there is a lament that fragmentation has led to work being 'ad hoc' and that working better with fragmentation might allow for interlinking between the 'wider system' and the feeling of the scientist that they were part of 'meaningful work.'

> If we sorted out some of the kind of wider system issues, the satisfaction for me as a researcher would be improved, and I would feel like I was part of projects that would have meaningful impact in the world rather than just ad hoc little bits and pieces here and there. (NZ interview)

Governance is also a useful concept when comparing ecological and social fragmentation around biosecurity. The evolution from an ecological definition of (landscape) fragmentation to one of responsibility broadens our perception of where the biosecurity problem lies. A decade ago, in response to a narrow definition of ecological fragmentation, the biosecurity response focused on structural and physical responses. This has been evident in biosecurity policies that call for the protection of borders and which conceivably create a more fragmented notion of biosecurity threat. Biosecurity policies outside of Aotearoa include fragmentation more in their biosecurity approach, an indicator that fragmentation may be a norm for governance and, indeed, ubiquitous in new understandings of forestry management.

> We're talking fragmentation of governance and … responsibility, are we? To me, fragmentation, as an ecologist, means something quite different. […] [I]f only we had continuous forest … rather than pieces are isolated by pasture and so forth … it could be a component of that fragmentation narrative. (UK focus group)

Normative fragmented biosecurity governance was discussed as part of the 'architecture' of colonisation. In the case of Wales, the devolved nation is subject to the same regulatory framework as England but does not have access to the same decision-making processes and may disagree on the core focus for biosecurity protection. While approaches are loosely integrated, it is represented here as 'conflicted' (Biermann et al., 2020) and with vague understandings about who gets to make decisions and what happens in practice.

> So in Wales … there's a long history of colonial issues…. [Wales] is an annex … not a … proper devolved country [like Scotland] and [it stings]…. [I]f you were talking about what happens on peoples' land, and the decision making … around biosecurity, who gets to make those decisions and where those powers come from, that it might come up. (UK focus group)

Each way of reconceptualising who should be involved in governance and decision-making adds new qualities to fragmentation with different consequences for engagement, success and value in their work (Biermann et al., 2020). These qualities highlight the affective dimensions of governance, which are positive when aspects like the volume of work and time involved in managing fragmentation are supported. This includes attention to governance structures and functions that, in the context of fragmentation, avoid processes that are overwhelming or risk burnout, that allocate sufficient organisational time or value to the work involved in managing fragmentation, and support the management of project outputs that satisfy its multiple dimensions. Alternatively, the experience of poor governance is described here:

> So you're acting reactively instead of strategically. You're fragmented because you don't have the time to keep and to maintain those connections with the other groups and keep on top of what else is going on. (UK focus group)

Following on from this, in a colonial context, governance does something in addition. It helps us assess the level at which participants usually excluded by colonial practices felt willing to be engaged in the decolonial opportunities involved. Notably, we have previously proposed that a fragmented biosecurity approach might offer opportunities that are specific to excluded groups, allowing for the integration of different interests and knowledges, and potentially increasing equity. For knowledge but also governance, fragmentation reflects the potential for setting up alternative processes within a part of that system. Yet, the processes of change here too are acknowledged to be very slow:

> We've still got a lot of connecting to do … a lot of infrastructure to put in place…. Ten years ago … it was just the pathologists … entomologists and … foresters … and now it's become a societal issue, so I think we have come a long way in ten years. (UK focus group)

> Change will be slow…. [we are] slowly realising that we're working within systems, which there is a long distrust. (NZ interview)

> I feel like we could do so much better within the system without even necessarily addressing a lot of the inherent parts of it, just by doing a better job of setting up our own processes … [but] it's hard [to disentangle] what's [the] systemic problem. (NZ interview)

While participants gave different accounts of fragmentation and colonisation, the arguments in favour of fragmented governance were infrequent. Instead, fragmented governance seemed to bring more harm than good, as it was generally seen as an extension of colonialism. This seems to raise the question of how to decolonise biosecurity. The participants offered some perspectives based on how

colonial institutions had been opened up, but this raised questions about the nature of biosecurity and its inclusion of a place-based approach to ensure that localised and informal processes of governance can be part of the wider decolonial approach. This is discussed next.

Fragmentation of places (communities and trees)

Due to the nature of our research, there is a geographically segmented dimension to both colonialism and fragmentation of biosecurity, which we review here through a place-based analysis. In Wales, the fragmentation of the biosecurity system was a colonial legacy of devolution, but colonialism itself was low on the agenda and largely accepted as part of the ways in which biosecurity was managed. In Aotearoa, colonialism could not be ignored and addressing it was critical to addressing imbalances in both knowledge and governance:

> Colonial biases. Well, that's where it's come from. Right? That's the source of the imbalance. (NZ interview)

> Te Tiriti has two partners, so it's important settlers do address postcoloniality. (NZ interview)

> In a way, England has got us over a barrel a little bit, because we're always going to be reliant upon them to do the things that we need to do, especially when we're talking about skills, knowledge, lab capabilities, access to plant health inspectors, and things like that…. Scotland has shown it can work, but ... they're ahead of us. (UK focus group)

The concept of place has always been central to biosecurity research. There are two key concepts of place that have implications for the understanding of colonisation and biosecurity fragmentation. The concept of place as a (1) boundaried geographical place in which colonialism is a threat from external forces contrasting with the fluid and transgressive nature of tree pathogens as seen in work by Simard (2021); and the concept of place (2) as the cultural and physical meanings about a landscape which shape understandings about colonialism and how responses to threats are made. The quotes below show these different elements of place-based thinking in the Welsh context:

> Biosecurity has no borders, but I wondered…[what] our perspectives on what English-centric biosecurity policies, interpreted through a Welsh devolved government lens, means for Welsh landscape[s]. (UK focus group)

> Welsh culture is … totally grounded in the landscape: the poetry, the art, things like that. (UK focus group)

Focusing on place meanings might show how applying cultural and social as well as geographical context to biosecurity is not a universal phenomenon but that differences in the contextualisation of place are a response to either the identification of a threat from outside a border or one that may be more amorphous in nature. The participant below also believed that biosecurity reflected a species-dependant view of biosecurity threats and failed to account for a community-based view of place-based meanings:

> So trying to keep it simple, for something that's quite amorphous and quite … and I want it to be amorphous, I don't want it to be prescriptive, because otherwise it will lose its appropriateness to everybody, so it's right woodland in right place, rather than right tree in right place. It's right woodland in right place for the right reason for that community. That's what it's about. (UK focus group)

The concept of place meanings potentially offers a bridge between a forestry management plan and an approach that emphasises an individual species response. By keeping biosecurity amorphous, there is room for manoeuvre. In a forestry management approach, the management of the threat (in this example of Kauri dieback) addresses how the forest is perceived and used by the community along with the overall health and wellbeing of the forest:

> Māori are often looking in a far more holistic way. You know, we're talking the difference between a forest management plan compared to a Kauri dieback management plan. Whereas one is, you know, far more inclusive of everything that goes into looking after the health and well-being of that forest and would require a lot more people around the table to have that conversation in a productive way. (NZ interview)

Therefore, a place meanings approach is an improvement on a segmented fragmentation approach, which would assume differences in biosecurity management between Aotearoa and Wales across that same tree species, but may not look at holistic management. The incorporation of context, meanings and value, as well as local responses to colonialism, provides an opportunity to better reflect a multi-faceted management of tree threats, both at a national but also within local contexts. However, the integration of a place meanings approach with colonialism requires further conceptual thinking to have wider applicability to the fragmentation of biosecurity and decolonisation. An awareness of place meanings, for example, does not make a distinction between colonial processes that have taken land (and its associated spiritual, practical and physical dimensions) and those claiming authority over knowledge and decision-making (and other forms of governance). Although, in the following quote, an empathy for the implications of the loss of land emerges when there are opportunities to reflect on place meanings.

This fragmentation speaks to the land ownership issue and the fragmentation of a rural way of life and communities:

> The risk of land buy up … [has a] … possible impact … on Welsh language, on breaking up communities, etc. and impacts of multiplier effects on those communities – loss of agricultural staff, loss of farms, and all that sort of thing. (UK focus group)

By taking a more holistic approach, one where you focus on your relationship to and sensory experience of the ngāhere (guided by a kaumatua) is in the words of a participant one where:

> You're reconnecting with what biosecurity is all about: the environment. (NZ interview)

Reconciling abstract biosecurity for forestry or trees with place meanings brings a recognition of the importance of land ownership and wellbeing that would have been overlooked if it had been a matter of biosecurity alone. The importance of place meanings rather than segmentation showed that different communities and trees responded to colonialism differently and that an appreciation of place meanings seems as important as our previous attention to knowledge and governance to help inform us about many ways in which colonialism affects biosecurity.

Discussion: Fragmentation and Learning with Pathogens

The idea of biosecurity fragmentation was introduced as having social (involving people, communities and even politics) and ecological dimensions. This paper explored the possibility of different forms of fragmentation (segmented, stratified, structural, and functional), but empirical analysis of the interviews presented a biosecurity system that was fragmented in terms of knowledge, governance, and place meanings. These overlap with segmentation (Aotearoa/Wales), stratification (knowledge), structural (governance) and functional (places) fragmentation, but the analysis *combined with colonialism* brings about new insights into the fragmentation, revealing a paradox where it is part of the solution to the colonialism of science, as well as a consequence of it. With respect to the latter, fragmentation was generally considered to be detrimental to a holistic approach to biosecurity; although when place meanings were considered, fragmentation seemed to offer some possibility for understanding and responding differently to colonialism in individual contexts. It may open the possibility for community-orientated, landscape-based responses to biosecurity management.

Notably, in describing a phenomenon like biosecurity as fragmented, Zürn & Faude (2013) caution that it is tempting to assume it existed as a whole or was experienced as shared. Fragmentation may not be the issue. Rather, it is a feature of governance that is neither appropriately differentiated nor coordinated. Critical

social theory takes up this point to suggest that fragmentation is not an anomaly. Fragmentation was a feature in both places, evident in the different knowledge, governance and place meanings needed for biosecurity. The empirical evidence showed how fragmentation in each of these different contexts worked against biosecurity operating as an encompassing system. Rather, responses pointed to the multiple threats to ecosystems, the diversity of policy, science and public approaches and the differentiated responses which normalised the fragmentation that is shaping biosecurity.

Several of the interviews referred to the consequences of fragmentation in Aotearoa and Wales for institutions like DOC and NRW, but also for communities (Māori). As the focus of this paper is to consider the consequences for and of colonialism for biosecurity science, the findings highlight the general point that fragmentation has consequences for colonialism. We have shown, too, that fragmentation may be exploited to perpetuate colonialism through excluding, delaying or diminishing Māori input or, in the case of Wales, where a reliance on central rather than devolved structures, along with underfunding relative to England, puts effective biosecurity management at risk. Furthermore, even the practical provision of biosecurity becomes a matter of colonial politics, with knowledge gained from Māori communities being incorporated into the biosecurity system, such that it loses its capacity to be distinct. In the context of devolved politics, it means being marginal to centralised biosecurity decisions.

In the interviews, we specifically sought to ask about what the pathogens are teaching us, not what colonialism is. Drawing on the postcolonial theories of Appadurai (1988), fragmentation is not necessarily a negative for biosecurity. If the proliferation of different systems and approaches in Wales and Aotearoa is seen as a way of managing specificity and identifying the unique assemblage needed in each place for successful outcomes, it could be seen as a positive response to a largely diversified set of pathogen threats and effects. Fragmentation could be expected and anticipated as part of colonial processes. But our work indicates/highlights that a discourse of legitimacy affects how fragmentation in the context of colonialism is perceived (Zürn & Faude, 2013). This realisation provides opportunities to develop biosecurity responses tailored to address pathogen threats and specific issues of land and power, taking into account the differences between Māori communities, some of whom have settled Treaty claims and others that have not. What emerges is that fragmentation may be positively conceived as a part of the vitality and dynamic of changing and responsive communities of peoples, trees, forests and threats (Dietz, 2003), rather than seeking holism as an overall political goal of biosecurity. Equally, this recognises that it is important to support and privilege the strengths of diversity, collaboration and partnerships that emphasise the crucial role of Indigenous Peoples and local communities in delivering positive biodiversity and biosecurity change (Friedman et al., 2022) (see our work on rubric development that supports this activity).

Conclusion

This analysis has revealed that there is a range of understandings about colonialism and what it means to overcome colonialism in Wales and Aotearoa. More overtly, in Aotearoa, we paid attention to the colonisation of peoples, places, and knowledges (and their relationship), whereas, in Wales, the focus was more narrowly on people or places. The questions this leaves us with are, whether there is a positive role for fragmentation in biosecurity or this thwarts the desire to work with biosecurity as part of a whole system. Furthermore, what is the role of biosecurity *science* in shaping or responding to the fragmentation of science knowledge, and can colonial processes be overcome or do they require new ways of thinking and working? This analysis seems to support the finding that fragmentation is an important area to support good relational links that underpin research and agency position statements around what is said to move us towards good biodiversity and biosecurity management (e.g., in NZ, see MPI's Biosecurity 2025 Direction Statement), Maybe working with biosecurity fragmentation could offer new opportunities for strategic action towards pathogen threats that encourages care for tree health and resilience, and good relationships between Western and Indigenous sciences. Attention to the role that biosecurity science knowledge across places may help us to attend to other ways of knowing (i.e., mātauranga Māori and more-than-human perspectives) as a key process shaping colonial biosecurity practices.

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Author contributions

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Notes

1. Māori is a term that emerged during the colonial era to refer to the Indigenous people of Aotearoa New Zealand, in opposition to the British settlers (Steward, 2020, p. 10). However, it is important to note that Māori people are composed of many tribal groups with diverse genealogies and histories, as well as dialects, technologies and skills developed to thrive in the different geographical areas that each group inhabited. This heterogeneity and diversity must be considered whenever the collective term is used.

2. According to Global Forest Watch, between 2001 to 2020, New Zealand lost additional 1.3 Mha of tree cover, equivalent to a 11% decrease in tree cover since 2000. Those numbers include the pine plantations (now promoted as carbon sink and as an economic and environmentally friendly alternative to cattle farming). The loss of primary forest is biggest. In 2021 alone, Aotearoa lost 9.15kha of natural forest (Global Forest Watch, n.d.).

3. Kauri was logged until the brink of extinction, then logging was banned, and it lost its economic value (swamp kauri came to the rescue and was for a while the most expensive timber in the world. Eventually, the damage inflicted by illegal diggers on the wetlands was so important that the government was forced to intervene (Ministry for Primary Industries, 2020).

4. Whether Ireland or Wales (or even Cornwall) is the first colony is debated, however for some historians, the formal annexing of Wales predated its Irish equivalent. Regardless, all were subjected to key features of colonialism: military conquest, settlement, cultural assimilation (including language), political subjection, economic and resource extraction, with identities shaped by English colonialism often in pejorative ways (see Johnes, 2019).

5. For a rousing speech on Welsh history, see Price (2009). Many similar texts remain spoken or written in the Welsh language and views expressed often do not appear in the public domain.

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