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Park Rangers and Science-Public Expertise: Science as Care in Biosecurity for Kauri Trees in Aotearoa/New Zealand

Marie McEntee[1] · Fabien Medvecky[2] · Sara MacBride-Stewart[3] · Vicki Macknight[2] · Michael Martin[1]

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Abstract Park rangers hold a unique set of knowledge—of science, of publics, of institutional structures, of place, and of self—that should be recognised as valuable. For too long, models of the knowledge of scientists and publics have set people like rangers in an inbetweener position, seeing them as good at communicating, translating or negotiating from one side to the other, but not as making knowledge that is powerful in its own right. In this paper we argue that focus groups with park rangers across regional and conservation parks in Aotearoa/New Zealand reveal the complexity and multiplicity of rangers' knowledge-making that shows the science-public model as incomplete. We argue further that the model is flawed for its focus on the making and holding of knowledge and not also on how it is enacted. Rangers, we argue, are responsible every day for making knowledgeable decisions for the health and well-being of parks and people. Making good decisions, though, requires not just knowledge but also care. An understanding of the many ways rangers know and enact their knowledge is important for biosecurity practice, especially in models of adaptive governance.

Keywords Biosecurity · Kauri dieback · Rangers · Expertise · Care · Adaptive governance

✉ Marie McEntee
m.mcentee@auckland.ac.nz

[1] School of Environment, University of Auckland, Auckland, New Zealand

[2] Centre for Science Communication, University of Otago, Dunedin, New Zealand

[3] School of Social Sciences, Cardiff University, Cardiff, United Kingdom

Introduction

The discourse on public engagement with science, most notably in the public understanding of science tradition, often assumes a dichotomy between the techno-scientific world on one side and 'the public' on the other (Stocklmayer and Bryant 2012) or between experts and non-experts (Kallimanis et al. 2017). Indeed, in his historical review of participatory approaches to science, Lengwiler (2008: 186) "distinguishes four periods since the late nineteenth century, each with a specific relationship between expert and nonexpert". Although the binary of expert ⇔ non-expert has long been discussed and problematised in STS (see Collins and Evans 2002; Lane et al. 2011; Nowotny 2003), embedded in this dichotomy is a demarcation between those within the techno-scientific institutions and those outside. Expertise, it has been noted, crosses this boundary in multiple and complex ways. Unlike the expert ⇔ non-expert binary, the science ⇔ public dichotomy stubbornly persists, though not without its changes and challenges.

Over the past two decades, much work has been done on how to enact the relationship between public and science, most noticeably with the growing literature on dialogue, participation and co-production of science. Indeed, "The move from 'deficit to dialogue' is now recognised and repeated by scientists, funders and policymakers" (Stilgoe et al. 2014). In doing so, both the way *science* and the way *public* are imagined has also changed significantly. The latter, in particular, has moved from a view of a singular public to a mushrooming multiplicity of various publics, each with their own cares, concerns, values and knowledges. This, it has been suggested, has acted to blunt the success of the democratic aspirations of dialogue and participation, as the "contemporary crises of democracy and expertise, commonly rendered as matters of public deficits, can be seen as problems of too much (not too little) participation" with ever-dispersed publics (Chilvers & Kearnes 2020). As a result, while much has been done to increase and improve participation and co-production in and with environmental science particularly, these efforts yield limited results, are often very small scale and remain commonly science-led. Stilgoe and colleagues suggest "that such exercises do not sufficiently challenge, and so serve to reinforce, incumbent power structures" (Stilgoe et al. 2014). Worse still, institutions can use participatory processes to gain traction for their objective rather than to meaningfully engage their publics.

As the work on public(s) participation in and co-production of science forges ahead, much of the existing power dynamics seemingly remain unchanged. Indeed, in their review of participatory practice in environmental science, Turnhout and colleagues conclude that "co-production processes can end up reproducing, rather than mitigating, existing unequal power relations and that they often do not contribute to societal transformation" (Turnhout et al. 2020). In this paper, we start from the premise that there remains a conceptual binary between science and the public(s). As an exemplar case, the literature (both academic and grey) abounds with studies looking into how *science* can be better communicated to *the public* (Bickford et al. 2012; Brownell et al. 2013; Leuthold and Gilli 2019; Manzini 2003; Nielsen 2005; Treise and Weigold 2002). This binary is of particular

interest in this paper in the context knowledge making with a government-led science-based institution.

We analyse focus groups with park rangers in Aotearoa/New Zealand, which were undertaken to assist with the identification of forest users who present a high risk of spreading kauri dieback disease. These focus groups provide an insightful case for prying open the science ⇔public dichotomy, examining the rich and multiple knowledge that rangers hold, and revealing the important role that care plays in how rangers enact knowledge.

To make this argument we first spend some time in the literature to explore how park rangers fit into the dichotomous pairing of science and the public. We suggest that adaptive and flexible governance involving multiple stakeholders has emerged as a more dominant approach to biosecurity, as opposed to top-down natural resource management approaches (Cook et al. 2010; Evans et al. 2020; Rawluk et al. 2021). It is therefore important to understand who and what lies in the middle, and how those usually positioned in the middle contribute new forms of knowledge and perspective (Reed et al. 2015). Given that Aotearoa/New Zealand is considered a bio-secure nation with attention to its "border[s], boundaries and expertise" (Barker 2008: 1958) it is necessary to next explain the ecological and social context in which we have been working. Our article finds value in simultaneously constructing Aotearoa/New Zealand as a physical biosecurity-managed place (i.e. geographically-bounded) and a policy space for biosecurity management seeking to limit the spread of kauri dieback disease. Involving rangers in stakeholder mapping, we show the rich sets of knowledge they hold about the recreational users of regional parks in the top-half of the North Island. We present their knowledge of science and technical matters, of place and space, of multiple publics, and of their own limits. In each of these dimensions the rangers communicate how care for the forest animates their decision-making. To approach biosecurity policy through an adaptive governance model requires that we make a conceptual move to seeing rangers' role in its complexity and give voice to those, such as rangers, that sit in-between science and public.

Park Rangers and the Science ⇔ Public Dichotomy

Rangers occupy an unusual place in relation to science and the public. They are classically part of the techno-scientific institutions (national parks, council land management, etc). Their role in biosecurity science is largely technical (Kennedy and Broome 2019); implementing and monitoring biosecurity protocols (Buller 2008; Matos et al. 2018; Weerasinghe 2020) or acting as sensors to identify new threats (Jiménez López and Mulero-Pázmány 2019). Though infrequently considered scientific experts in their own rights, their 'scientific' role is usually limited to environmental communication, engaging in new forms of public science interpretation (for example, identifying the co-benefits of parks for people and nature, and reinforcing shared understandings of environmental impacts) as a way of distributing scientific information that does not view the public understanding of science from a purely deficit approach (Remillard 2016). Rangers also have informal science

communication roles that the public and the management expect them to have, i.e. walking encyclopaedias, willingness to discuss sensitive environmental issues—even with hostile visitors (p.52). The policies and strategies for park management position rangers as stewards of natural resources, institutionalising their accountability to the landscapes in which they work and to issues of climate change, biodiversity loss, and land use change that these landscapes may protect (Remillard 2016).

It is this unusual space that makes park rangers a particularly important case when considering the challenges raised by the science ⇔ public dichotomy. An upshot of the ontology imagined by the science ⇔ public dichotomy is that each individual, each actor, is either part of the techno-scientific world or part of the public, but not both nor neither. Again, there has been some acknowledged tensions here, with some actors inhabiting more complex spaces, notably intermediaries, and also practitioners. While intermediaries are sometimes interpreted in the narrower sense of boundary organisations (Guston 2001; Miller 2001; Smith et al. 2016), we follow Landrum (2017: 253) and interpret the term broadly to include both organisations and others that "serve consequential, communicative functions". Different intermediaries may have different publics, from 'the general public' to policy-makers (Cheng et al. 2008; Meyer and Kearnes 2013), but they share certain goals, from disseminating the science they see as relevant to stakeholders, to engaging stakeholders in the projects or the process, to having the science they promote being integrated into decision-making whether at an individual or policy level (Landrum 2017). Intermediaries play an interesting role as they are sometimes with one foot (or even both) in the techno-scientific world such as professional societies, scholarly journals, or university communication departments, though others are more removed (e.g. museums, private foundations or the press). Importantly, little is said of the role of intermediaries as epistemic actors. This is particularly important in light of the fact that, as Turnhout and colleagues state "many co-production projects are led by a rationale of science-driven impacts" (Turnhout et al. 2020). Intermediaries' role as communicators is well established, but their role as holders of scientific or scientifically relevant knowledge is left unstated. They sit in an epistemic limbo.

Practitioners, like intermediaries, are recognised as inhabiting a complex space. In some cases, practitioners are valued *because* and by *the fact that* they are intermediaries or 'boundary-spanners', defined as individuals who "dedicate their time to creating and enabling effective knowledge exchange" (Bednarek et al. 2015: 297). These authors acknowledge there may be more to such intermediary practitioners and that "individuals and organizations can play multiple or shifting roles in producing or using knowledge within the same process" (Bednarek et al. 2018: 1176). However, the kinds of practitioners imagined or assumed in this setting of boundary-spanners are intermediaries between science and policy-making, keeping 'the public' (however imagined) outside the decision influencing relationship. Rangers, who are often referred to as practitioners (Cronin et al. 2021; Kuiper et al. 2020; Wang et al. 2020), are usually imagined in a different way to what Bednarek had in mind. We propose this is because rangers' decisions are always 'for' the public (or nature, which is kept 'from' the public) so they are always in the relationship.

This complexity of rangers' role is shown in how they are represented as "trusted by the public, dedicated to science translation, and skilled at crafting stories for

multiple audiences ... ideal ambassadors for the science that gets left out of the public discourse" (Merson et al. 2018: 52), and as distrusted park officials who by virtue of being practitioners may not have be given first-hand scientific knowledge about landscapes they manage and whose scientific knowledge of an area can be poor or inaccurate as a result (Willenbrink et al. 2021). Rangers in both perspectives belong to the wider publics and as indirect recipients of scientific knowledge.

Rangers as a particular-type of practitioner-intermediary is established in research that focuses on their skills, knowledge, and training in support of the management and application of science in endeavours like biosecurity (Pierce at al. 2018). In the case of conservation areas, park rangers' scientific role may involve implementing and managing biosecurity science protocols for protected areas and species (Buller 2008; Matos et al. 2018; Weerasinghe 2020), often requiring specific training in the technical details (Kennedy and Broome 2019). Again, rangers are identified by the roles that they play in support of education, and public health (Wong and Higgins 2010) and through the type of knowledge that they are acknowledged to hold relative to other experts and non-experts (Lewis 1989). Park rangers' role as practitioners-intermediaries is not neutral because their relationship has been found to shape the ecological aspects of a park in positive and negative ways (e.g. shaping primates' behaviour in Mt Huangshan, Usui et al. 2014). Their role may also be controversial because their institutional role means that they are perceived to represent wider conservation and management goals (Christopher 1999) even while they are assumed to hold less sophisticated and skilled understanding of the landscape and the threats to it than the same management bodies (Carmichael et al. 2020).

As research has sought to challenge these prejudices and advocate for the inclusion of park rangers in management practice (Allen et al. 2018), it has aligned with new forms of adaptive governance seeking to extend the involvement of multiple stakeholders within the management of conservation areas (Cook et al. 2010; Davies and White 2012). Rawluk et al. (2021) have described adaptive governance in comparison to existing forms of management.

> "The conventional natural resource management paradigm of command and control (Holling and Meffe 1996) aligns with a parallel ethos around biosecurity, such as assuming that biosecurity can be managed as the patrolling of a border. By contrast, adaptive governance recognizes dynamism as inherent to a social-ecological system and such systems need to be holistically managed but cannot be controlled in a mechanistic fashion." (Rawluk et al. 2021, online)

However, in this case rangers represent something of an anomaly. Co-operative management approaches that consider rangers as having complementary or similar values to other stakeholders (Avriel-Avni et al. 2021) and directly involve them as co-researchers in decision-making and management decisions (Carmichael et al. 2020) are less prevalent in the research literature than those that use rangers' and others' (farmers, foresters) knowledge to inform higher-level decision-making (Etienne et al. 2002; Seijo et al. 2020), or to improve the flow of communication amongst stakeholder groups (Dorji et al. 2021; Willenbrink et al. 2021). Notably, it is rangers themselves who are rallying for change, arguing that their shared, engaged and tacit knowledge of an area, its cultural knowledge, and their particular skills.

Properly resourced, they could provide long term benefits for managing natural resources and conservation (Woodside and Vasseleu 2021). Simultaneously, Welch et al. (2015) raise the alarm that rangers have been directly impacted by resource issues leading to understaffing, time constraints, and professional development, so their capacity to be flexible, to deliver non-technical skills, and make decisions about resource allocations that involve local priorities, is compromised.

The case of rangers does raise some interesting questions about what counts as science knowledge, and what relevant epistemic contributions rangers make, or indeed if we need to rethink the role of practical, experiential knowledge in shaping science understanding (Sharpe et al. 2016). As science itself finds itself more highly politicized around environmental and land management issues, and involves concerns about uncertainty, care, geography and culture, there are important questions about the role of rangers' knowledge in facilitating public engagement and willingness precisely as science becomes more diverse, fragmentated and rich (Giraud and Hollin 2016; Robinson and Wallington 2012). These questions are not only being raised by SES scholars focused on engaging multiple knowledge-systems in successful adaptive management, but instead raise broader issues about the political, affective and nonlinear relationships that exist between science and society, culture and nature, professionals and other kinds of experts more generally (Carrillo 2021). The overall effect is an acknowledgement of the porous and partial nature of knowledge, which becomes evident when intermediary perspectives are involved.

The above evidence of the complex positioning of rangers within the public engagement with science space as practitioners-intermediaries has provided this study with a strong rationale for inviting rangers to share their perspectives on biosecurity and forest users. This engagement activity with park rangers in Aotearoa/New Zealand in the context of biosecurity management provides an exemplar of the middle ground between science and publics, and as a way to revisit the positioning of knowers in our science-public ecology.

Study Context and Methods

Biosecurity incursions in Aotearoa/New Zealand forests present enormous challenges for public agencies responsible for biosecurity management. This is particularly true for the invasive pathogen *Phytophthora agathidicida* that is infecting Aotearoa/New Zealand's iconic kauri trees (*Agathis australis*) (Beever et al. 2009; Waipara et al. 2013). The resulting disease known as kauri dieback is currently incurable and when present in individual kauri trees is usually fatal (Beever et al. 2009). It is a significant ecological threat given that the once abundant kauri forests have already been devastated by timber milling and forest clearance during Aotearoa/New Zealand's pioneering years, with a mere 0.5% of the original coverage remaining in small strongholds in the northern forests (Beever et al. 2009; Steward and Beveridge 2010). Significant efforts are now underway to protect kauri as they are recognised as a keystone species and regarded by Māori, the indigenous people of Aotearoa/New Zealand as a taonga or treasure because of their prominent

role in the creation narrative and their intrinsic connection to Māori identity (McEntee et al. 2020; Waipara et al. 2013; Weir et al. 2015)

Kauri dieback management is a highly complex and contested space. Initially management focussed on a partnership approach between affected iwi (indigenous tribes) from kauri lands, central and local government agencies, and research institutes. However, the partnership became increasingly strained as concern grew over the leadership and insufficient funding of research by the lead agency, the Ministry of Primary Industries (MPI). Widespread criticism of the Ministry's Kauri Dieback Programme led to its eventual replacement in 2021 by a National Pest Management Plan which grants significant protection for kauri and the establishment a dedicated kauri protection programme known as Tiakina Kauri (Ministry for Primary Industries 2022). The programme is co-governed by Māori and the Crown, in collaboration with the Department of Conservation (DOC) and the regional, city and district councils across kauri lands.

Councils are responsible for the administration of parks and reserves in their respective areas. Auckland Council for instance, manages over 4000 parks, covering 52,5000 hectares (Auckland Council 2021). They employ around 80 park rangers who are supported by volunteer rangers and a team of short term contract rangers over the busy summer months. Council park rangers are responsible for protecting both the natural and cultural heritage of the parks. They work alongside contractors who are engaged in weed and pest control, park nurseries, farming, track upgrades and maintenance, and managing and maintaining visitor amenities. In addition, park rangers play important education and enforcement roles to enhance forest users' awareness of forest biosecurity measures and increase compliance.

The Department of Conservation (DOC) also employ rangers, who work on the DOC estate. In regards to kauri dieback management they assist with track upgrades, cleaning station installation and maintenance and recently began implementing a behaviour change programme to assist with building greater awareness among forest users of the disease and control measures to prevent the spread of dieback.

The Park rangers' role in increasing public awareness and compliance around kauri dieback and other forest diseases, supports the Government's desire to develop a more resilient biosecurity system by improving awareness and understanding of forest health and involving citizens in biosecurity protection (Ministry for Primary Industries 2016a). This is reflected in Aotearoa/New Zealand's 'Biosecurity 2025 Strategy', a policy document which seeks to develop "a team of 4.7 million" whereby every New Zealander should see it as part of their responsibility to contribute to the country's biosecurity by becoming a *de facto* biosecurity officer (Ministry for Primary Industries 2016b).

As kauri dieback is transmitted in-part by the actions people take while they visit forests, significant attention has focussed on forest management and control measures, including installing hygiene stations to clean forest users' footwear and equipment with disinfectant on entering and exiting forests and access controls, including exclusion zones and controlled area notices, that restrict or prohibit access to forests (Auckland Council 2021). Particular attention has focussed on identifying and working with high risk forest users to prevent transmission and contain the disease, as the Northland Conservation Board's Chairman stated, "everyone visiting or working in

our forests—from forestry workers, trappers, and pig hunters to recreational users such as trampers or mountain bikers, must take responsibility to help stop the spread of the disease" (DOC 2015).

Typically, management of high risk forest users occurs through regulatory and/or educational means largely to change aberrant behaviours and increase compliance. This is complemented by enhanced biosecurity controls such as track upgrades and improved cleaning stations and in significantly affected areas, by total forest closures. However, both central and local government recognise that protecting kauri from invasive pathogens will require much more critical engagement with innovative social science approaches to more deeply engage with forest users, particularly those that are deemed to be high risk users.

It is in this context that the present research was developed as a three-year project to employ a citizen social science approach to enable diverse high risk forest users to make decisions to protect the health of managed forests, and then using the biosecurity actions and measures they prefer, to ultimately undertaking these actions themselves. The project's first year would focus on gaining an understanding of high-risk (HR) user groups and how these users/groups relate to, make sense of, and interact with the forests. The second year would involve 'in-place' methods, including the development of virtual 'in-place' approaches to enable discussion *in* forests with HR user groups. The third and final year would work with HR groups and agencies to create a space for interaction between forest user groups, rangers and policy-makers to co-create biosecurity tools (including policies) to enable a more inclusive, user-centered, problem-solving process in urban and periurban forests.

Citizen social science is a form of citizen science where citizens take an active role as research partners facilitating social action and/or behavioural or cultural change as collaborators and co-designers of the research. Citizen social science therefore embraces participatory action research that seeks to actively engage and empower communities (Cornwall and Jewkes 1995; English et al. 2018; Woolley et al. 2016). In this way citizen social science reflects Irwin's (1995, 2001) framing of citizen science as a way to democratise science through collaborative partnerships and transformative learning compared with traditional 'contributory' approaches to citizen science where community members act primarily as data collectors (Ruiz-Mallén et al. 2016). Citizen social science provides a means to both engage with forest users to demonstrate what actions could be taken to improve forest health, and to investigate how to learn about recreational forest use/rs to enhance ongoing biosecurity interventions with additional voices and perspectives. Our method also draws from work highlighting how meanings and local practices around place can be mobilised in citizen science (Mohamad et al. 2015).

In this article we discuss the focus groups undertaken in year one of the project with park rangers in four forest regions of northern Aotearoa/New Zealand to assist with identifying high risk forest users. These focus groups, undertaken in the rangers' own meeting spaces provided access to valuable on-the-ground insights from the rangers' practical 'know-how' experience of working on the front line of biosecurity conservation.

The focus group format involved an interactive activity to identify and map the high-risk user groups at each site, using topographic basemaps supplied from Land Information New Zealand at 1:50,000 scale[1]. Two members of the research team (MME and MM) facilitated the activity, using an open questioning style to encourage discussion and to ensure that the task was completed in the time allowed (between 45 and 90 minutes). The visual data is presented in another paper. The discussions during the mapping exercise were audio recorded and transcribed, and it is the analysis of this qualitative data (undertaken co-jointly by the research team; MME, VM, FM, SM, MM etc) that is presented here.

Findings

Using the perspective that rangers have access to scientific, technical and social knowledge, this section provides a detailed analysis of the rangers' expertise, experiences, and their discourses of forests, forest users, and biosecurity management and risks. The analysis draws out the rich sets of knowledge that rangers hold, and which incorporates a complex understanding of place, the rangers' sense of the multiple interests and needs of different publics, and a self-reflective sense of their own limits. This represents the rangers' knowledge about science and about publics that resists efforts described in the literature review to set rangers neatly inside a model with science on one side, publics on the other, or even as simply in-betweeners.

In a 2013 paper based on in-depth interviews with park rangers in Australia, Howard described the varied roles that rangers must perform. Beyond the technical roles that people might imagine being the bulk of ranger work lies management: leading projects, priority setting, communication, resource allocation, and multitasking. "Park rangers", Howard goes on to explain, "fulfil these roles in a business environment that has ambitious targets, answers to a variety of stakeholders with competing and conflicting views, has limited resources, and severe time constraints" (Howard 2013: 248).

There is recognition, then, that this is a complex job requiring a range of skills and knowledge. We want to think through some of the subtleties and nuances of the knowledge rangers enact on the job, while managing biosecurity, as revealed by our focus groups.

In the section that follows we will discuss four aspects of ranger knowledge: technical, place-based, about the multiple publics who visit their parks, and about themselves. Each of these aspects leads us towards a different source of nuance. Enacting technical knowledge is an embodied act, and rangers' embodiment creates nuance. Living places, with all the change, growth and movement they contain, creates nuance in knowledge. Knowing publics, with their varied and

[1] Land Information New Zealand Topo 50 Series maps at 1:50,000 scale were used. They are the highest resolution maps and data available. Land Information New Zealand has a 1:25,000 for areas of significant national interest (for example, resource extraction), though none had coverage of the study areas. More information may be found at: https://www.linz.govt.nz/data/linz-data/linz-basemaps

sometimes competing actions, intentions and beliefs, creates nuance. And, finally, knowing oneself, and the ways one reacts to pressures creates nuance. (We note too, that our discussion does not bring up the cultural or spiritual knowledges that rangers may hold since these were not a topic in our focus group. For a detailed and beautiful discussion of how these aspects of knowledge can be vital for environmental management and beyond, see Fox et al. 2017).

Throughout, 'care' emerges as a salient theme for park rangers. This occurs in the context of their biosecurity obligations, including in conflicts between technical and management aspects and their management of the social and public uses and users of the parks. Ultimately, we argue that the literature's modelling of the dichotomy is an incomplete and a limited picture of the rangers' knowledge. In light of how they apply a discourse of care to both science and publics, we argue that aligning rangers to either science or publics is overly constrained. This argument and our final conclusions are verified by returning to the literature on tensions and discourses of biosecurity science and communication within the context of adaptive governance.

Rangers' Technical Knowledge

Raymond and colleagues have written about the embodied knowledge humans have about eco-systems, setting this view against one of disembodied scientific realism. In their view, the nuance in the relationship between humans and nature comes from the relations of mind, body, culture and environment, and this can be contrasted with a view of nature that assumes it can be known by a set of straightforward acts of reason and measurement (Raymond et al. 2018). More, the technical itself is always enacted in ways that are embodied, material and in-place. Rangers enact a high degree of scientific knowledge around the causative organism of kauri dieback and its management. Some of this knowledge is about the technical details of disease control, including knowledge of required dilution of disinfectant (sterigene) at cleaning stations for the various sized containers used in the parks as shown in the following discussion. Importantly, it is knowledge enacted with bodies and eyes, as well as with water, sterigene, and containers.

> Ranger 1 - He goes 'I think I put four hundred litres in'. So I was like 'did you put any sterigene in', and he's like 'no, it would have just been diluted with the other stuff that's in the container'. It's like 'how big's the container?' He reckons it's a thousand litre container.
> Ranger 2—It's not a thousand litre.
> Ranger 3—I don't think it's a thousand litre, it's five hundred litres max

The rangers' technical knowledge also extended to their knowledge of the soil. They understand how soil is moved within and between parks on different users' footwear, tools, and tyres. For example, when talking about the differences between trampers (multi-day walkers), runners, and dog walkers, a ranger commented:

> Ranger: It's whether you're going quickly or slowly and in some ways a lot of the running shoes are probably lower risk because big tramping boots with big heavy deep lugs collect more soil.

They are able to use their scientific understanding and their access to labs, to answer a question that they are curious about, to extend knowledge of in-place disease risk. This is seen in the following example around hygiene cleaning stations.

> Ranger—So, years ago …, I took two soil samples and submitted them for testing. One was taken from two foot falls outside a sterigene station and that came back with phytophthora but it didn't determine which particular species. The other one was a soil sample taken from a brush used to scrub people's shoes. That came back with phytophthora again, without determining the species.

Rangers' knowledge of micro-organisms (Phytophthora) and soil movement allows them to make sense of written policies and procedures, including Standard Operating Procedures (SOP), and how they apply to the places where they work. It helps rangers interpret procedures to reduce the risk of disease transmission.

> Ranger—When I read the kauri dieback SOP you have to get cattle from outside of the kauri range … so then there's no risk of kauri dieback.

This technical application of scientific knowledge enables rangers to respond to problems as they arise as well as adapt that knowledge to local conditions. What has been perceived to be just a technical skill is in fact a contextual and responsive approach, requiring embodied knowledge.

However, rangers also noted the role that care plays in enacting their technical and scientific knowledge of kauri dieback. For them, this care is vital for turning information into knowledge that matters; knowledge that is cognisant of the impacts of human activity on kauri in the parks. We see this in the contrasting views of how care transforms rangers' knowledge, compared to others who they perceive care less.

> Ranger—I mean, you give us all the information but we're people who actually care about the information. Some people you'll give the information to and they'll be like, "that seems unlikely to me", but we know the impacts.

Rangers Have a Nuanced Knowledge of Place

Clearly forest parks are places of diversity, and not just in the biological sense of bio-diversity but also of their geographic area, and the social and cultural diversity of the people who visit, live near or care about the park. Clearly too, as living spaces forest parks change over time. Movements of water, animals and micro-organisms, are an inherent feature of parks. When these diverse places meet the network of a tree disease and the bio-security mitigation put in place to limit its spread, we have a highly complex set of networks that can intersect, contradict, get confused, concede, adapt and accommodate (Hinchliffe and Bingham 2008). The rangers' discussion

showed their rich and subtle understanding of the landscape and the ways this relates to the networks of disease and biosecurity. This included contour and water flows; a nuanced view of the relationship between place and activity; and an understanding of these elements in combination and how these shaped the biosecurity risk.

The initial focus of the rangers' discussion about high-risk groups was to distinguish between those who were 'on-track' versus 'off-track' users of the parks. Specific labels emerged for those who did not obey the rule of staying on-track (e.g 'wanderers'). Rangers were able to differentiate different groups based on their understanding of how these groups used place differently and this was an important way in which the rangers identified each groups' relative biosecurity risk. In one case, this nuanced understanding of place was the reason that trappers were constructed as low risk at one site but not at another.

> Ranger 1—[Trappers] generally do everything right […]
> Ranger 2—Yeah, we didn't pick them as high risk, did we? I guess it's just that they go to high risk areas.

This nuanced understanding of the geography of the park meant it was possible for the rangers to not only differentiate between different groups, but also to show how the changing geography within each place shaped the riskiness of groups, and therefore the management needed to reduce their risk.

> Ranger 1—You could differentiate them a little differently. Walkers and trampers are a little different because they're staying front country, you know, high use tracks which are generally going to be better maintained, whereas there are trampers, more back country, probably off the beaten track slightly more.
> Ranger 2—[…] I guess it's [high risk] those bits where you're not particularly confined to a catchment and [and at least one area that] is at least one single catchment, um, yeah, and we could write a rule that said start at the top of the hill and work your way down, that's the safest way to manage it.

They talked about how biosecurity policy, infrastructure and tools or architecture could be considered as part of the physical geography that contributed to shaping the relative biosecurity risk of each group. This was most obvious when the rangers talked about how the lack of facilities provided for mountain bikers in some areas meant that, when mountain bikers entered those areas, the nature of the place identified them as high risk. It was also present in their awareness of how nuances of place are shaped by policy which underpins the management of the parks.

> Ranger 1—Though I suppose you've got those [cyclists] who go to the areas where we ask them not to and the stations aren't particularly well geared for them. There's few [mountain bike] roads through quality bush, you'd be sick of steps.
> Ranger 2: In [another area] where the mountain bike tracks are, they're non-kauri [tracks]. So, they're in specific locations… [Here mountain bikers are low risk]. Whereas here, you've got people sneaking in all over the place not

doing any of those steps. They're riding on tracks with kauri. [Here mountain bikers are high-risk].

The rangers' nuanced understanding of place and its relationship to biosecurity risk also contained both affective or place meanings, and value. The rangers discussed how as groups moved around the park they may be more compliant in some places because protecting that space had particular value to that user group. This was the case for trail runners who wanted to protect the kauri so that they could continue to run there (see also MacBride-Stewart 2019a, 2019b). It was also seen with families where the forest had intergenerational significance, and for the permitted or legal hunters who, due to valuing a place in which they were legally allowed to hunt, were largely compliant.

Ranger—they're grateful they still have a place they can still come to hunt pig because there's no other options that I know of in the region. You have to go further south or up north to do similar and even up there in those places they're restricting that because of kauri.

Rangers' nuanced knowledge of place meant that they understood the different points of entry for each group, where the groups are mostly found, and the areas of damage that each group was likely to have been responsible for. However, even more importantly, rangers constructed each of these places with particular and distinct challenges for how to manage each groups' specific risk to kauri. For example, it was the inability to know where instagrammers would be; the locals stated attachment to place; the canyoners love of inaccessible steep terrain; the mountain bikers appeal for tracks which crossed official tracks and paths; the hunters running dogs off-leash (and inevitably off-paths) and staff vehicles that 'go everywhere in the park', which posed the greatest risks.

Ranger 1: And the locals have, I mean especially, … it's like the rules apply to the other people but not us because we're local because we have this elevated status.
Ranger 2: How many times have you heard that: "I'm local".

The rangers' nuanced understanding of place which included affective, infrastructural, and geographical dimensions shows the extent to which their knowledge extends well past evaluating the success of boot-washing stations at park entrances. Instead, rangers provide a sensitive and informed knowledge of how limited these biosecurity efforts might be in light of their dynamic understanding of place.

Rangers' Nuanced Understanding of Multiple Publics

Rangers understand that different publics who come into the parks have different sets of knowledge and different things they care about and this presents rangers with the challenging task of managing the risk of a variety of publics. Rangers are responsible to the many people who come to their parks with different intentions and beliefs. This is particularly so during times of bio-security challenge, such as

kauri dieback. For Howard, a key role of park rangers is their combined role as disturbance handler and spokesperson: "park rangers need to deal with a range of competing public expectation. Rangers often talked about the dilemma as 'competing ideologies' and the need to find a balance (or compromise) amongst stakeholders" (Raymond 2103: 244) In our focus groups was shown the nuanced knowledge coming to play in the ways rangers talk about and deal with the multiple publics in the parks.

We see this clearly when we look at the ways rangers manage contractors, such as track workers. Rangers' task is to ensure there is an alignment between what rangers care about (forest health) and what contractors care about (meeting their contract conditions and then getting paid). However, as the following quote indicates, to do this well, rangers need to know about the contractor conditions.

> Ranger—So you're contract managing, so you're going out like mid-work seeing … they're using machinery and stuff. But they might have hygiene stations set up on site and they might have different boots and stuff, all sorts of different controls put in place for the various people…We are harder on these guys than our own staff to be honest…We have someone to hold them to account, they're not going to get paid if they don't adhere to their conditions.

Here the knowledge of the contractors may be knowledge of the rules more than knowledge of the science behind kauri dieback. Yet the care the rangers show (being harder on contractors around boot cleaning than on their own staff) and the contractors' incentive of being paid for work are used to support best practice.

However, contractors are not the only publics that rangers deal with. Different groups, who have quite different goals from each other are understood by rangers to have different things they care about. This means that rangers act in different ways with the differently knowledgeable—and differently caring—publics.

With volunteers, rangers have a strong sense of the care that lies behind their work and believe that the ranger's role is one of support. The volunteers care about place, seeing the forest as their "backyard".

> Ranger—They'd say, I've been living here for so many years and this is my backyard. I have an obligation to care for it…There's a whole lot of different, conversations happening in the volunteer space, but I think a lot of them talk, [as if they are] fortunate, privileged, to be able to work in these spaces, and ours is to support them, make sure they are safe.

With volunteer trappers, rangers recognise that their care extends beyond one place. It is the wide-ranging 'pest' species like possums, rats and stoats they care about eliminating for the good of the forests. Rangers recognise this wide-ranging care brings risk too, such as the transmission of disease between forests.

> Ranger: If you're a trapper you're quite often trapping somewhere else too. You might trap your local neighbourhood and help your neighbour and then you also happen to be trapping in the park and you also happen to go and trap here, and you can be a wide–ranging trapper.

The rangers' approach to dog walkers is also revealing.

> Ranger—We'd talked to them, try and educate them, 90 percent of them will say, 'oh but I know my dog, I can control it'. Yeah, depends on the ranger, some don't mind turning a blind eye, and if the dog's not misbehaving and if it's a back-country track, yeah. And for us it's mostly about education, just talking to the owner about why you put your dog on a leash.

At first, the above quote might suggest rangers take a communicator approach, standing between science and publics in the role of translator and to some extent this is certainly the case. However, it is also more complex, with different rangers making decisions about how to deal with dog walkers differently depending on where they are and how the dog is behaving. This again shows rangers working multiple roles with nuanced views of the relations between publics and places, and the differential risks involved.

Here Rangers relate responsible action to care. They determine the potential risk posed by researchers who visit the forest to undertake their studies.

> Ranger 1: How does this group [researchers] act in relation to the forest? They care, they look after it.
> Ranger 2:—Yeah, just say they do everything right.
> Ranger 1—Yeah…They generally do everything right.
> Ranger 3—They try to.

Rangers decide that researchers pose less risk because they care, do 'everything right' or at least try to. In contrast, people who know the rules but do not care about them present a significant risk.

> Ranger 1:—How do you label that, people who are, who don't care about rules? Freedom people?
> Ranger 2—Eco-terrorists.

Rangers' understanding of their multiple publics also allows them to recognise where gaps in their knowledge of their publics lie. This, for example, is a conversation about 'dope growers' responsible for the cannabis plants that are sometimes found growing in parks.

> Ranger 1: Oh yeah. Yes, definitely. We have them on camera, they exist.
> Ranger 2: But they sometimes disappear.

Rangers also know about the different material things that accompany their publics. Across the conversations with rangers we hear mention of boots, traps, machinery, hygiene stations, cameras, dogs and their leashes, as well as information, conversations, and council rules. This means they are well placed to understand how technical biosecurity requirements intersect with the other pressures people feel and their possible reactions to requirements.

> Ranger 1—I think, like, we've got a digger operator, he has to clean his digger down, massive (inaudible) and he has to between jobs and he's getting

> told to do that by us, you know, when he moves to another site. So he's seeing …
> Ranger 2—He's probably saying stop wasting time doing that shit, because …

Expressing the diversity between publics, the rangers also understand the diversity within groups. In this example—the driver of a four wheel drive vehicle (4WD) represents a risk not only by being 4WD, but by having access to high performance vehicles and having an attitude of ownership.

> Ranger: That's when you come back to the user attitude thing there's people who want to do a high risk activity or what we think of high risk like let's say 4WD. So, say someone just bought a $70k Land Cruiser that they're going to drive at the beach and they've like got their amazing bit of gear. They've got no experience, so they're going to get stuck or get drowned or flip over and stuff or die. You've got some old dude whose got all this experience, got the right gear and he just cruises up there goes fishing stays on the beach no problem. Then you've got the other dude whose got the high performance, we're going to go anywhere because we can, we're going to charge through the forest, cut fences, go hard. That's our user group up there (laughs).

Rangers' Self-reflective Sense of Their own Potential for Risk

As Howard has discussed, rangers need to be able to multi-task, with limited resources and under time-constraints "The on-the-job" realities of life as a ranger can impact on a rangers' behaviour, where time and other pressures lead to the poor implementation of rangers' own knowledgeable actions, such as boot cleaning. Rangers are aware, at least in retrospect, how these competing claims upon them can create risks. A self-reflective knowledge of their own actions is a part of the nuance they bring to their role.

> Ranger 1: We may be under more time pressure, especially staff and contractors, but the time pressure thing can actually be a hazard to us because we do, you know, even though we should be following best practice our time pressure can prevent us.
> Ranger 2: And we might do it, we might clean our boots, [but] not make the best cleaning

We see that rangers' commitment to giving one type of care to the forest interrupts their application of other knowledge (boot cleaning), and as knowledge of the risk this poses to kauri. In 2018 Kurt Jax and co-authors described care as relevant to conservation in three ways: "first, as a relational and context-sensitive approach to justification of conservation measures, second, as an attitude that is focused on the well-being of (particular) others, and third, as a (variety of) concrete practices rooted in culture, religion or emotion" (p. 26). At times, rangers reflect, these types of care are difficult to do simultaneously. When working hard to get a job done,

including off-track for the general well-being of the park, it can be easy to let other types of care slip—hygiene measures for kauri dieback, for example. This is how some of the park rangers reflected on the relationship between the work they need to do and the knowledge they have of risk. In the midst of their care work in practice they do not always remember what else they know, despite their attitude of commitment towards kauri and other species in the park.

> Ranger 1: We're committed, I mean, we've committed to being able to walk off–track I suppose. And also, yeah, geographical spread.
> Ranger 2: We're often usually working as well, trying to get something done and not thinking about …
> Ranger 1—What? Who? What? You're not thinking about it. You become complacent basically.

By inviting rangers to map the park users we deliberately engaged them in a methodological activity that moved the discussion away from rangers' technical and management knowledge of the biosecurity stations and signage and, as reflected in the above examples, revealed and highlighted the nuanced knowledge they have of biosecurity risks across each park.

This showed that rangers are holders of unique knowledge about risk in the parks they work in. They know and care about the technical and scientific matters of kauri dieback, and they know complex and material things about the multiple publics who interact with the parks. They do not just stand between science and publics in a translator or communicator role, although sometimes they do. They also work in ways unique to them, based on their knowledge of place, and of the material things that are in, and are brought into, that place. It is knowledge of the complex and multiple publics that use the park in a variety of ways. It is a knowledge animated by the care they enact for the forest, a care that takes hard work and which sometimes forgets to clean its boots fully. Rangers know and understand the science of kauri dieback and the technical measures put in place to control it, and they understand the ways different people, including themselves, add risk to the forest.

What rangers know too is how to make good decisions, about risk and forest health, and these decisions go well beyond communicating or translating. They know how to embody and perform the role of ranger in specific places. This makes rangers akin to nurses—institutional caretakers in health structures, with a unique and rich set of knowledge. Like nurses, rangers' decisions are set in motion by their knowledge and because they care.

We argue that rangers' commitment to, and care of the forests they work in, both sets them apart, and illuminates the problems of thinking about knowledge as a static thing. Instead, rangers' daily work requires that they use their knowledge to make particular decisions that they regard as in the best interests of the forest. Partly this is framed by their institutional knowledge of rules and structures handed down from councils and the Department of Conservation. Importantly, rangers' decisions are also set in motion by the care they have for the forests.

Discussion

We suggest a useful way to think about rangers would be to dispense with the science/public dichotomy altogether, and instead think about the knowledge of scientists, publics, rangers, and so forth in terms of how it is in-place and embodied. This will be a familiar thought for those who know the work of Latour, Pickering, and other (see, for example, Braidotti 2006; Latour and Woolgar 1979; Pickering 1993; Salleh 2017). This would see a scientist knowing their bio-chemistry in relation to their pipettes and petri dishes, academic papers and lecture slides; and dog walkers in relation to their dogs and leashes, the weather and the tracks they walk, and hygiene stations and warnings posted on gates. It would simultaneously value the work of the ranger who, in sharing a sense of place with the dog walker, is also actively using their knowledge of science, place, dogs, boots, hygiene stations, and publics to make care-full decisions about risk and forest health.

So far we have worked to bring to light forms of nuance in rangers' knowledge—coming from embodied relations with the material world, from the flows of place, from the negotiations with multiple publics, and from reflection upon themselves. How does thinking past the science/public dichotomy expand our understanding of what is knowledge in the biosecurity and environmental space? What types of knowledge would biosecurity research become better placed to notice and value?

First, it would help build understanding of the importance of place in the complex on-the-ground decisions that rangers bring into play at different moments. Partly these depend on what scientific knowledge and what knowledge of publics is relevant at a given time. Rangers' decisions also depend on where they are in the forest—what trees are around, whether the track is wide and gravelled or muddy, how far they are from hygiene stations, and more.

Second, it would help build understanding about the relevance of material things, including boots and hygiene stations (how they are encountered and experienced) but also in the context of forest users lived lives of to-do lists, encroaching darkness and tired legs. This helps build understanding that sometimes knowledge of science, publics, forest health, and risk matter less on the ground than human problems of time pressure and complacency—or that they come to matter differently across places and reasons for being in the forest. It can be important to see places where care slips, the ways that knowledge and material context interfere. These can end up as gaps in biosecurity practices. This reminds us that risk, and its practical enactment and reduction, is part of the material and lived context of everyday practices that rangers work in.

Third, it could help break down an implicit hierarchy of knowledge that is embedded in the idea of rangers as translators or communicators standing between science and publics. In that model, science is difficult and publics need help understanding it, and of course this is sometimes true. Yet what matters to *multiple* publics is difficult to know about. This is because it requires understanding about each group's experiences about what, for example, a healthy forest looks, sounds and smells like or how to manage different expectations, meanings, values—and as this paper has considered—practices. Thinking about a ranger's knowledge as in-place and

embodied helps us recognise the difficulty and importance of their knowledge, not because it is somewhat scientific, somewhat social scientific, or somewhat communicator, but because it is all these and *more*.

Fourth, and most importantly, it helps noticing that care often has a role in the creation of good knowledge, which in the case of rangers is care for each place as an eco-system, a geography and as a destination (MacBride-Stewart 2020). As our findings show, when talking about what contractors, volunteers and trappers care about, rangers understand that knowing what people care about is important. In 2018, Lisa Sharma-Wallace and co-authors published a review of adaptive governance efforts which

> "foregrounded the complex, messy human, and not quantitative or technical, dimensions at the core of adaptive governance, with development of trust, respect for stakeholders, and community and organisational social capital underpinning each of the methods as well as most of the successful cases" (p. 181).

This reinforces our argument that it is necessary to stay aware of the complex set of knowledge that rangers have about place, material things and multiple publics if we are to build trusting and respectful partnerships with rangers. In addition, we suggest, it is important to notice how rangers care about the places they work in and the ways this animates their knowledge and their decisions. This helps us see how past knowledge held in heads and into how care-full decisions are made on the ground.

Conclusion

The commonly repeated dichotomy of science on one side, public on the other hides much from view. It is a dichotomy that imagines a specifically ordered world, a world where knowledge not only resides in discrete spaces, but also exists independently of its embodiment. In this paper, we push back against this dichotomy, and against the world it imagines, by drawing attention to the role of park rangers in biosecurity management. Rangers, we have argued, are a group of people who hold a rich and nuanced knowledge of science, of place, of multiple publics, and of their own limits. If we limit our thinking about rangers to ways they work in the in-between space—as communicators, say—we do not also see how much they know and nor how they enact their knowledge. We might also forget the ways that their care animates this knowledge, supporting their commitment to forest health. In fact, we note that care may be the missing discourse for effective adaptive governance (Hatfield-Dodds 2006).

To approach biosecurity policy through an adaptive governance model requires that we make a conceptual move to seeing rangers' role in its complexity. This includes their understanding of places that can flow unbounded, their sense of the multiplicity of human networks, and their awareness of the moments when they are limited in what they know and can do. Understanding rangers and their knowledge

in this way, we believe, is a necessary condition for respectful partnerships and effective policy.

More than that, our study shows the importance of giving a voice to those that sit in an epistemic limbo because they are neither clearly within science, nor clearly within the public (Latchem-Hastings 2021). It speaks to the role of rangers as 'environmental caretakers' with all the epistemic voices we think such caretakers should (and sometimes) have, both at the decision-making level and for those of us researching knowledge in this space.

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