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Towards an Agenda for Social Science Contributions on the Human Dimensions of Forest Health

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1 Introduction

Although there is still much to learn, we can find a substantial body of work on understanding the ecological dimensions of tree pests and diseases, but until recently the much needed analysis on the human dimensions has largely been missing despite acknowledgement of the significant part that human behaviours and decision-making play in tree health. The chapters in this book and the references that they cite go some way to address the human dimensions gap and to lay the foundations for future social and economic research in tree health. The IUFRO working party (7.03.15—Social dimensions of forest health) strives to bring together social scientists and economists working on tree health

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issues and provides a forum for sharing ideas, knowledge and methodologies from across the globe in recognition that pest and diseases cross many sociocultural, economic and political borders.

There are a broad range of trees and their associated pest and diseases, native and non-native, covered in this book including Acute oak decline, Asian longhorn beetle (ALB), *Phytophthora ramorum*, Ash dieback, Emerald ash borer, Oak processionary moth, Mountain pine beetle, Dutch elm disease, *Xylella fastioda* and more. In this context of outbreaks of tree pest and diseases, management and adaptation or future threats, researchers in this book have worked with many stakeholders including local communities, indigenous peoples, scientists, government agencies, NGOs, businesses, policy and decision-makers in villages, cities and rural forests. Many of the chapters in this book highlight the significance of collaboration, partnership and engagement, which suggests that better biosecurity necessitates inclusion of different knowledges, values, expectations and aspirations. Allen et al. (Chapter 11) underline why it is important to involve stakeholders in tree health highlighting that people must be given the opportunity to have a role in decision-making that affects them, but also greater participation ensures that social, cultural and economic impacts are also considered alongside ecological effects (see also Marzano et al., Chapter 12; Davis et al., Chapter 15). Often there is a focus on the consequences of tree health rather than the causes as these often seem too complex and difficult to control (Dyke et al., Chapter 17), perhaps requiring changes in people's behaviours such as recreationists visiting forests, consumers purchasing plants, producers and traders importing or selling live plants and wood products, those involved in large-scale planting programmes or forest management generally (Marzano et al., Chapter 12). However, Urquhart et al. (Chapter 7) and Price (Chapter 10) warn that there is no simple way to capture the interests, concerns and responses of individuals and groups and several chapters highlight ways in which local narratives of disturbance compete with scientific ones (e.g. Mattor et al., Chapter 14; Lambert et al., Chapter 5; Prentice et al., Chapter 4; Gürsoy, Chapter 3). Culturally embedded conceptions of the natural world often inform the construction of, and responses to, pest and

disease outbreak events, and thus, it is important to incorporate an understanding of human–nature interactions as well as different agencies (human and non-human) into pest management deliberations (e.g. Prentice et al., Chapter 4; Fellenor et al., Chapter 6; Dandy et al., Chapter 16; Dyke et al., Chapter 17; Williamson et al., Chapter 2). It is also necessary to place tree health concerns at local scales within a wider global context of market pressures, harvesting practices, formal regulations and governance processes (e.g. Dragoi, Chapter 13; Keskitalo et al., Chapter 8; Jones, Chapter 9).

To understand, analyse and communicate about the complex tree health landscape, the authors in this book have adopted a variety of research methodologies and tools such as literature reviews, social media analysis, historical documents, face-to-face interviews, workshops, questionnaire surveys, Q methodology, rubrics and scenarios or narrative development. Through these different approaches, the chapters make important contributions on the human dimensions of forests and tree health in different geopolitical and sociocultural contexts. This chapter attempts to summarise the contributions, all of which are needed to inform tree biosecurity policy and management planning, and concludes by proposing an agenda for future social science research in this field. The synthesis presented in the following sections incorporates knowledge, values and attitudes, governance processes, risk communication and engagement and different way of investigating and understanding tree health.

2 Values

What people value will have significant implications in terms of their own behaviours and action as well as their acceptance of management responses. Gürsoy (Chapter 3), for example, highlights that villager perspectives on tree health crucially depend on the values they attribute to different trees. In the forest villages of Turkey, fruit trees found in gardens and orchards are particularly significant for their economic value. Gürsoy explores the symbolic spaces that trees inhabit such as

the garden (domestic), orchard (domestic), forests (wild) and how this influences villager perspectives on who has responsibility for monitoring of trees and any interventions. The majority of forests are owned by the state, and Gürsoy notes that while forest pests are observed by villagers, unless they appear in the domestic space, pests are felt to be the responsibility of others, even though forest villagers have the right to utilise their local forests.

The difficulties of managing for pests and diseases when there are multiple, competing stakeholder values and interests is exemplified by Prentice et al. (Chapter 4). In the USA, they found that community responses to the catastrophic Mountain pine beetle (MPB) outbreak in Colorado was structured through several lenses—the local economy, policies and the biophysical landscape—but also how they interact with nature (e.g. livelihood versus recreation). Prentice et al. present a number of key stakeholder viewpoints on the reasoning for the MPB epidemic. The forest service suggests that lack of 'aggressive' management has led to a proliferation of mature forest stands that are aesthetically pleasing but vulnerable to MPB attack. Industry stakeholders see the MPB outbreak as a result of a diminished industry presence and point to wider conservation priorities (carried out by the forest service) that limit silvicultural practices to create habitat for designated animal species. The environmental perspective identified native MPB disturbance as important for forest succession and believe that forests will eventually recover. The potential impact of pest management on biodiversity is of greater concern than the pests themselves. There were also divisions between local communities with the more affluent and recreation/amenity-oriented communities supporting minimal intervention. Less affluent communities whose livelihoods were, or had been, linked to the forest industry were more supportive of intensive forest management and felt that these bigger outbreaks of MPB were a result of their disenfranchisement from the forest. Thus, Prentice et al. demonstrate how powerful environmental narratives are constructed within entangled sociocultural, environmental and economic histories that all play a role in how pest threats are perceived and acted upon. These findings chime with Urquhart et al.'s (Chapter 7) Q methodology study of residents in

a community in South East England affected by Ash dieback. Here, perceptions about management and concern about the impacts of the outbreak were related to people's fundamental environmental worldviews, such as their beliefs about the vulnerability or resilience of nature, together with their beliefs about whether Ash dieback had arrived in the UK on imported nursery stock or had blown in on the wind.

3 Contested Knowledges

While there are a growing number of studies that highlight low knowledge levels amongst a range of publics on tree pests and diseases (e.g. Marzano et al. 2015; Fuller et al. 2016; Urquhart et al. 2017), Lambert et al. (Chapter 5) and Mattor et al. (Chapter 14) investigate important issues around whose knowledge counts. In New Zealand, Lambert et al. explore how Māori indigenous knowledge is contesting mainstream science perspectives on tree health. Calling for joint approaches to managing tree pest and diseases, they highlight the need to bridge the cultural gap between local indigenous knowledge and western scientific views of forests and their management. This call is not only for Māori representation in decision-making or governance roles but also including Māori methods and priorities for protecting forests. There is very little published evidence on the impacts of pest and diseases on social and cultural values and identity. In this chapter, Lambert et al. present the example of Kauri (a sacred Māori tree species) dieback (*Phytophthora agathidicida*). Local Māori have responsibility for all Kauri on their tribal land, and a failure to protect Kauri reflects on the *mana* (respect, authority, status and spiritual power) of tribal elders and future generations. The urgency of responding to Kauri dieback has led to greater involvement and leadership from Māori and involvement of Mātauranga Māori (knowledge and wisdom) at all levels of management including development of a Kauri cultural health index. Māori approaches to measuring impact include how people feel spiritually when they enter the forest—an assessment that does not sit well with traditional quantitative approaches to risk assessment and can be met

with resistance from the western science community. The recent development of the Māori Biosecurity Network is a move to empower participation of local peoples and ensure that indigenous voices are included in wider biosecurity issues.

Gürsoy (Chapter 3) also emphasises that forest villagers will not always have the same understanding or perspectives as tree health scientists and that there should be greater dialogue and respect for local knowledge. At the same time, villagers signalled a desire for scientific knowledge on new and emerging diseases and for mitigation activities in forests for trees they value. As with many of the chapters in the book, Gürsoy highlights a need for greater collaboration amongst key stakeholders such as the forestry administration, villagers and scientists. Like Prentice et al. (Chapter 4), Mattor et al. (Chapter 14) also researched the impacts of MPB, but in this case study the authors were concerned about drinking water resources. The over-arching aim of the authors was to explore differences in knowledge bases between water managers and scientists and to assess the extent to which there was knowledge exchange about impacts in principle (scientific data) and practice (water managers' experience) between the different parties. Underlying the proliferation of the MPB epidemic is climate change with warmer weather creating drought stress in conifers. Tree mortality in large numbers can create problems for watercourses in terms of water quality, yield and flow. The authors maintain that while successful knowledge exchange can lead to changes in attitudes and behaviours, cultural differences between water scientists and managers over what constitutes evidence act as a barrier to interventions. In presenting scientific evidence, there is often a lack of understanding of what informs manager decision-making, which is often not based on scientific research but more on past experiences and traditional approaches. Mattor et al. suggest that scientific research often does not take into account tacit knowledge so research findings can have limited application. When surveying water managers, those who indicated high knowledge levels did read published scientific evidence and were more likely to be involved in collaborative water programmes. Nevertheless, the authors identified low levels of knowledge relating to MPB impacts

compounded by the fact that managers had not yet experienced any evidence of detrimental effects linked to the beetles. Thus, stakeholder perceptions of risk and interpretations of actions required were entirely different to the recommendations of scientific research.

4 Understanding Risk

Urquhart et al. (Chapter 7) specifically focus on risk perceptions, emphasising the need for a good understanding of how experts and publics view risks around tree health. How risks associated with tree pests and diseases are perceived at multiple scales will play an important role in attitudes and behavioural responses. Thus, we need to know more about factors influencing risk perceptions including official pest communication, social networks, personal experiences and trust in those who manage outbreaks (see also Porth et al. 2015; Mackenzie and Larson 2010). Using Ash dieback as an example, Urquhart et al. highlight the complex interactions between government bodies managing disease outbreaks, media coverage of outbreak events and the diverse and adaptive risk perceptions of stakeholders and publics. The authors employ the Social Amplification of Risk Framework (SARF) to investigate how people make sense of different risks and the interactions between risk communication from external sources and their own identities, values, beliefs and experiences. They found that experts' view of risk was relatively dynamic and drew on a wide range of evidence, not just technical risk assessments and official information but less tangible forms such as prior experience, social networks, anecdotes and the media (see also Matter et al., Chapter 14). Policy makers were sensitive to reputational risk, and thus, tree health decisions were made that related to perceived social acceptability (and to be seen to be doing something) rather than empirical evidence of real impact or concern. Urquhart et al. note that risk understanding is not a linear process and that policy and expert priorities can be reassessed in light of media and public scrutiny. A key element, they suggest, is trust in the governance process and the institutions responsible for managing and communicating about the risk.

5 Governance and Collaborative Processes

The governance of tree health and analysis of existing governance structures is an important contribution to tree health studies, particularly in scoping the contribution of non-state actors to biosecurity processes and practices (Marzano et al. 2017). Many of the chapters in this book investigate and recommend collaborative processes and partnerships because, as Keskitalo et al. (Chapter 8) point out, while there is range of potential legal instruments and incentives, challenges remain with implementation on the ground. Keskitalo et al. emphasise the complexities within the European plant health system dealing with free trade between member states as well imports from non-EU states (see also MacLeod et al. 2010; Holmes et al. 2017). Health certificates such as plant passports for risky plant material are one way for national authorities to regulate and monitor potential threats, but Keskitalo et al. suggest that plant passports are not standardised across Europe and do not include non-regulated (new and emerging) pests. Crucially, higher-level regulatory systems cannot control the minutia of daily practices across a range of sectors that may threaten biosecurity. The authors present a case study of the nursery sector in Europe characterised by a strong system of inspection. Citing a survey of plant nurseries, the authors describe how nurseries identified a concern about pests and diseases and maintained that they regularly check plants for known pests. However, they also acknowledged 'risky' practices such as reusing storage containers that have been washed rather than disinfected, untreated water sources and failing to check plants that are purchased from another nursery. Keskitalo et al. noted the importance of collaborative processes for raising awareness and building capacity for better biosecurity, but they also highlighted limited integration between agencies and nurseries and between nurseries and research.

In this book, authors are quite right to point out that much existing work on the human dimensions of forest health often focuses on individual values but not so much on collaborative groups or collective action. Increasing threats to forest health have fuelled new ways of collaborating as we have seen with Lambert et al. and the Māori Biosecurity Network (Chapter 5). In the USA, Davis et al. (Chapter 15)

map the development of forest collaborative groups (FCGs) as a way for state forests to communicate with a broad range of local stakeholders including environmentalists, forest industry, local communities and others as well as handling differing (sometimes competing) interests over forest management and resources. The areas where FCGs are being trialled is characterised by a declining forest industry and loss of livelihood (see also Chapter 4). As they are voluntary entities, Davis et al. explore how FCGs work in practice and ways in which they could be improved. FCGs were set up to identify social acceptability of forest management interventions, avoid litigation from those disagreeing with the interventions and speed up planning timelines. The authors found that FCGs were generally more successful when there is a collaborative body or group that can organise and sustain itself. However, they did find that forest health issues to be discussed were primarily introduced by the forest service or scientists although some FCGs were starting to lead with their own knowledge and perspectives or funding their own monitoring programmes. Davis et al. warn that not all stakeholders will participate in their FCG, and these groups do not guarantee that there will not be public objection to interventions. Although the focus of FCGs appears to be on wildlife issues, they do provide a useful framework for thinking about pests and diseases and collaborative processes and can provide a snapshot of stakeholder views over forest management issues. Key lessons were that consultation responses from FCGs are dynamic and do not represent an enduring social licence to operate; rather, collaboration is an iterative process. FCGs are not legally organised entities that employ staff and have access to funds so there is a need to manage expectations of what they can achieve. FCGs currently operate in isolation, and Davis et al. felt that there was scope for greater knowledge sharing and learning between the groups.

6 Knowledge Exchange and Research Tools

Developing tools to facilitate knowledge exchange was a key feature of a number of chapters. Jones (Chapter 9) maintains that there is a strong economic argument for public support of plant health policies.

However, Price (Chapter 10) poses the question: how do you value impacts of tree diseases? He then goes on to explore whether contingent valuation is a useful method to assess whether it is worth expending resources to control or mitigate effects of pests and diseases. Price suggests that some services have a market benefit like water regulation and carbon dioxide fixing but other non-market goods such as cultural services (e.g. aesthetics) are more intangible. Thus, economics have looked to provide these values through contingent valuation like Willingness To Pay (WTP) for environmental improvements or to accept compensation for deterioration. Both Price and Jones highlight issues with validity and accuracy of valuations. Price (Chapter 10) calls for careful design of WTP questions and suggests that while it is useful to provide participants with enough information so that they can make informed judgements, there is a danger that too much information will prompt expectations that responses should be based on expertise and judgements regarding the public good rather than simply their own 'self-interested' preferences. Price advises that questions be neutral and refrain from value-laden terms such as 'disease'. Regardless of research responses, there is still an issue of how to translate economic findings into policy-relevant recommendations. Jones (Chapter 9) ponders on which economic methodologies can provide the best information in the shortest time—to fit in with policy decision-making in the context of significant uncertainty—and with limited resources. Jones advocates the use of bio-economic models to help assess the effectiveness of different management options on natural resources. Notwithstanding the need for empirical data, which is often lacking (see also Marzano et al. 2017), integrated bio-economic modelling can help determine the economic efficiency of interventions such as prevalence when found (how established is it), predicted rate of spread, judgements of impacts per host, the value of the host (to ecosystem services including human well-being), efficacy of control options and engaging stakeholder interests and capacity.

Stakeholder engagement was the key theme for Allen et al. (Chapter 11). A number of the chapters in this book have already observed growing recognition of the need for partnership-based approaches to tree health that include multiple stakeholders and their perspectives. Allen et al.

note that it is rare for biosecurity programmes to provide practical guidance or tools on working in multi-stakeholder contexts requiring not only expertise in technical activities but a greater understanding of organisational and social processes. The authors discuss an action-research approach with biosecurity agencies in New Zealand to develop a rubric, signalling a move away from top-down communication to greater engagement and dialogue and trust building. The key aim in New Zealand is to enhance the surveillance system for pests and diseases, and rubrics, the authors suggest, can be a template to instruct and evaluate activities and provide a framework for learning. Agency relationships with communities can be developed during periods of 'quiet' (e.g. surveillance or monitoring) in preparation for crises situations (e.g. eradication of incursions). Allen et al. maintain that rubrics can aid in developing communication and engagement processes but also facilitates thinking through the 'bigger picture' of biosecurity so it is both a long-term learning process and product.

Approaches to learning was a key element for Marzano et al. (Chapter 12) who focus on technology development for early detection of pests and diseases. At present, most countries rely on trained inspectors to detect pests and pathogens, mainly via visual inspections. However, given the volume of inspections required, the finite amount of resource usually available and the huge practical challenges associated with these inspections, this task is extremely difficult and the efficiency of detection is low. Thus, the authors highlight the demand for new and better methods for detecting tree pests and pathogens along trade pathways and in the wider environment. They highlight that technological innovations require close collaboration and interactions between researchers, end users, manufacturers and markets set within the broader context of social norms and the regulatory environment. The authors discuss the use of a learning platform, a concept that builds on learning alliances (Sutherland et al. 2012) which encourages multi-stakeholder knowledge exchange, dialogue and social learning to promote greater engagement and input into outputs and outcomes. In the context of early detection technologies, the aim of the learning platform was to move beyond provision of information or broader consultation towards greater decision-making and active engagement with the process of

technology development. The learning platform involved having to engage innovative tools to attract the interest of participating stakeholders and to encourage scientists to present technological ideas and invite feedback in accessible ways. Marzano et al. explored how evolving interactions between individuals and groups can influence the scope and speed with which technologies are developed. However, it is not a linear process and technologies are unlikely to be fully functional in a normal funded project lifecycle of 3–4 years. Rather, technology development is often supported by previous projects and other ongoing projects. In this context, fundamental questions were raised around 'who pays?' as tree health technologies are not merely products for consumer consumption. Will the lack of market potential (because of a narrow user base) limit innovation and what is needed to provide non-market-based stimulus? The authors believe that stakeholder engagement through the learning platform did influence technology development and raised important questions about how products move from concept to production and use. However, they recognised a need to be able to assess by how much stakeholder engagement can improve the socio-technological innovation process to encourage the prioritisation of participatory approaches over other activities.

This book also includes useful tools and research that have wider implications for tree health and biosecurity in the future. For example, Dragoi (Chapter 13) explored the development of a training tool to assist forest managers in selecting which trees should be kept as standing deadwood for biodiversity to meet FSC criteria. The tool is being trialled in post-socialist Romania where tracts of forests, formally under control of a communist government, have been restituted to landowners. However, the transition has been difficult particularly as the private sector is required to follow the same forest code as state-owned forests with little guidance on how to manage their forests. Forest managers and landowners face further difficulties of moving to a new system of certification and environmentally-sensitive logging due to an increasingly fragmented and bureaucratic governance system that has led to overharvesting and rent seeking. The tool (inspired by operant learning theory) encourages social learning and is focussed on training foresters to identify which trees should be harvested (healthy, salvage and sanitation) and which should

be left in the forest to grow or as standing deadwood. The training will help foresters to consider multiple issues (e.g. harvesting, biodiversity obligations, disease management) and is likely to be more cost-effective in terms of the time required to visit forests for each single issue. The tool will also allow foresters to continually collect data for monitoring and facilitates reflections on what constitutes a healthy forest.

How people engage with knowledge and information about the world has changed dramatically over recent decades, especially with the growth of digital technologies. This, asserts Fellenor et al. (Chapter 6), has implications for how tree health issues are viewed and understood by stakeholders and publics. The authors undertook a rapid evidence review on User-Generated Content (UGC), which relates to blogs, social networking sites, wikis, social commerce sites and discussion or opinion (e.g. trip advisor) forums. They found little detailed exploration of UGC aside from statements and assumptions that social media is a good thing. Many organisations and individuals will use the internet as one way of communicating with their audiences, and the authors suggest that UGC not only provides information to users and social networks, but users are themselves data sources. They note that UGC creates socio-technical material involving the trees, social media users and technological devices (e.g. smartphone monitoring systems). While UGC is never value-free, online interactive sites such as social media could be beneficial for forest health, providing real-time data. However, the authors warn that we don't understand enough about online communities and their relationships with forests and, consequently, there is a tendency to idealise what can be achieved through this interaction. Like Urquhart et al. (Chapter 7), the authors question how UCG and social media change our perceptions of the world and of ourselves.

7 Differing Approaches to Exploring Human Dimensions of Forest Health

Recently, Marzano et al. (2017) called for the inclusion of other social science perspectives that have been missing so far from explorations of the human dimensions of tree health. Historical analyses and ethics

are two disciplinary areas that can provide important insights into current concerns and priorities around pest and disease outbreaks. Both Prentice et al. (Chapter 4) and Williamson et al. (Chapter 2) highlight that more modern conceptions of nature, natural landscapes and how forests should look and feel are potentially contributing to their vulnerability to pests and diseases and that tree health should be viewed within a broader historical context. Williamson et al. take a historical approach to understand the potential contribution of forest management to pest outbreaks by exploring documentary evidence available in the UK from the sixteenth century onwards. The authors found that while there has been no large-scale pest or disease event prior to the twentieth century, tree health issues are not a new phenomenon and that the trade in live plants and trees existed—sometimes on a substantial scale—for centuries. They suggest that earlier generations viewed tree ill health as normal with diseased trees being felled and sold. Interestingly, the prevalence of oak, ash and elm in the British landscape only came into being from the seventeenth century despite there being at least 25 other native species that could grow into reasonably sized trees and were previously linked to specific regions and English counties. It is likely these species were favoured because of their ability to thrive in a wide range of habitats and for the value of their wood. However, an important difference compared with today is that trees were felled at a relatively young age or at least when they reached the size required for whatever commercial or domestic product was needed. The authors attribute the appearance of older, mature trees in the countryside with rapid social change coupled with the rise of conservation-based organisations with their own idealised constructions of nature and natural landscapes. This has led to unrealistic expectations in modern times that trees will stay healthy if left to grow into old age when history suggests that the most rigorously managed treescapes were the most healthy. Williamson et al. warn against continued conservation-based attempts to replicate existing woodlands and retaining large, over-mature and dead wood in the landscape, asking: are tree diseases an artifice of allowing trees to grow too old? Lessons from history indicate that the current 'artificial' landscape presents us with opportunities for the future by identifying a number of minority native species suited to specific regions that could make their comeback.

Social constructions of nature, forests and tree health are introduced in several of the chapters in this book. Fellenor et al. (Chapter 6) comment on how digital technology is increasingly mediating how some 'virtually' engage with forest health, rather than direct exposure or experience of tree pests and disease outbreaks. Dyke et al. (Chapter 17) were particularly interested in exploring ethical approaches to identify how humans impose their own values onto trees with the use of labels and concepts that often dictate who or what is allowed to live or be killed. Dandy et al. (Chapter 16) provide three different ethical framings to reflect on different approaches to management of Asian longhorn beetle (ALB). These framings—biocentrism, entangled empathy, flourishing—demonstrate how different approaches of seeing human–nature relationships can result in very different outcomes for managing forest health. For example, the biocentric approach insists that we remain neutral towards all species without favouring one species over another, which suggests that beetles, trees and human interests are equal and none should be harmed. However, biocentrism refers to a wild state in a natural ecosystem rather than non-native invasions. Entangled empathy, on the other hand, proposes multiple ways in which we have an active 'caring' relationship with humans and non-humans that feeds into discussions about whose lives should be prioritised in outbreak situations and where empathy may lie (e.g. could ALBs be viewed as refugees?). The flourishing framework involves the attribution of human values and perspectives such as decisions over what is healthy and able to flourish or not. Flourishing would dictate the felling of infected trees only (rather than all potential hosts) as these are unlikely to flourish. Dandy et al. stress that the development of narratives and alternative outcomes involving ethics and non-human agency doesn't mean that felling or other forms of pest management would be rejected, but the authors call for a 'noticing' of non-humans. Dyke et al. (Chapter 17) also emphasise the need to include non-human agency in considering tree health management and to move beyond scientific narratives of disease. They question management terminology around security, defence and invasion and advocate a focus on coexistence or living with 'invasive' species, which they stress does not equate to doing nothing but rather places constructions of health and ill health in the broader context of how trees, people, beetles and bacteria coexist in space and time.

8 Framing the Future of Research into the Human Dimensions of Tree Health

Taken as a whole, the chapters in this volume represent the first synthesis of social science approaches to address tree health issues and bring together interdisciplinary researchers from across the world to exemplify the diverse and rich contributions that social scientists can offer in tackling the growing threat from tree pests and diseases. As this field of scholarly interest develops, the book provides a useful applied and theoretical foundation on which to build an agenda for future research activity. In terms of a path forward, we suggest a number of key areas of focus.

Firstly, it is clear that dealing with tree pest and disease outbreaks is complex and involves navigating a broad set of actors at a range of spatial scales. This requires recognition of the diverse values that are implicated in tree health outbreaks. As contributions in this volume have shown, different stakeholders will have diverse, and sometimes conflicting, values about how outbreaks should be managed. Therefore, as in other areas of environmental management, stakeholder participation and co-management are an important strategy for successful outbreak management. This involves dialogue between stakeholders, outbreak managers and policy makers to build better governance mechanisms, and social scientists can provide empirical evidence to support this process.

Secondly, in a domain traditionally dominated by natural science, a key challenge will be to develop closer interdisciplinary engagement between natural and social scientists. Policy makers and research funders have a role to play in this regard, by recognising the value that social science 'evidence' can bring and by ensuring that policy processes support the integration of natural and social research (Marzano et al. 2017). As the economics chapters in this book (Chapters 9 and 10) suggest, economic models are good for estimating impacts on some ecosystem services, such as carbon sequestration, but less so for estimating impacts on cultural values, such as aesthetics, spiritual values or existence values. This is a gap that social scientists can help to fill, but long-term commitments to fund social science are required in order to build and sustain research capacity in this field.

Thirdly, while much of the book focuses on applied contributions, several chapters illustrate the rich and varied way in which social science can contribute conceptually. For instance, Chapters 16 and 17 in particular make important claims about the largely unquestioned anthropogenic approach to tree health management, arguing that environmental ethics can provide alternative lenses that consider the value of non-humans and, as a consequence, may shift management priorities.

Finally, tools, methods and conceptual frameworks are required that recognise the complexity and dynamic nature of the human dimensions of tree health. As such, this calls for drawing on existing and new innovative approaches from across the social sciences that are relevant in practice and address real-world problems. The editors and authors of this volume very much hope that other social scientists, and also arts and humanities scholars, will bring their own disciplinary expertise to this growing area of research that is the human dimensions of forest and tree health.

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