ON THE HUMAN IMPACTS AND GOVERNANCE
OF LARGE-SCALE TREE PLANTATIONS

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On the human impacts and governance of large-scale tree plantations

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Abstract

Because of the pace and magnitude of land cover change, terrestrial ecosystems across the globe are under unprecedented pressure. Industrial production of wood in large-scale tree plantations is one of the drivers of this change. The development of funds of natural capital on private lands for marketable commodities, however, often comes at the expense of other non-marketable benefits that people derive from ecosystems. The disturbances to existing ecosystems and social systems caused by the establishment of plantations can be drastic. Identifying factors that foster and impede actors and institutions to solve problems and address injustices thus becomes crucial for advancing sustainability through changes in policies and practices.

This dissertation synthesises findings from four articles. It takes on the task of filling two gaps in the previous scholarly literature: the first concerning the human impacts of large-scale tree plantations (articles I and II); the second concerning the different institutions that shape their governance (articles III and IV). It also brings these contributions together under a framework for empirical analysis, which combines and structures key concepts of environmental social sciences ranging from systems ecology to sociology. Both qualitative and quantitative research methods have been used in the four articles.

Article I presents the findings from a systematic review of the impacts of large-scale tree plantations for local communities. The review shows that impacts are frequently grounded in the process of land acquisition for plantations and the subsequent loss of livelihoods. Plantations have often caused more losses of livelihoods than created jobs. Article I also identifies gaps in the evidence base. Article II applies the concept of resilience and qualitative content analysis to analyse the Uruguayan beekeepers' experiences of and responses to land cover change to plantations. The results show that the community faces this change as multiple interlinked challenges (e.g., lower honey yields and higher costs), to which they generally have a limited capacity to adapt.

Both articles III and IV use data from the domain of South African tree plantation policy. Based on an analysis of policy beliefs, the former identifies two competing coalitions: a dominant *business-as-usual* coalition, of which ideas a minority *justice and change* coalition challenges. Article III also clarifies the role that beliefs concerning specific policy instruments play in coalition formation. Article IV focuses on policy learning – the acquisition and dissemination of information between actors with diverse knowledge. It tests hypotheses concerning actors' information exchange behaviour and finds that actors tend to exchange information and build trust with those who think alike. However, its findings support the idea that co-participation in policy forums enables policy learning.

Large-scale tree plantations have often caused negative impacts for local communities. The unfolding of impacts, however, also depends on the context (e.g., land use rights). The impacts are in many ways rooted in the governance of plantations, the dynamics of which can be better understood through coalition formation and policy learning.

Keywords

Advocacy coalitions; Belief systems; Ecosystem services; Environmental social sciences; Policy learning; Social-ecological systems

Tiivistelmä

Maaekosysteemit ympäri maailman ovat ahdingossa ja puuntuotanto teollisissa viljelmissä on yksi niihin muutoksia ajavista voimista. Luonnonpääoman tuotteistaminen yksityismailla tapahtuu usein muiden markkinattomien hyötyjen kustannuksella. Viljelmien aiheuttamat häiriöt niin ekosysteemeihin kuin yhteiskunnallisiin järjestelmiin voivat olla mittavia. Kestävyyden edistämiseksi ongelmien ratkomista ja vääryyksien oikomista estävien ja edistävien tekijöiden tunnistaminen on olennaista.

Yhteenvetoartikkeli kokoaa yhteen tulokset neljästä eri osatutkimuksesta. Se pyrkii täyttämään kaksi aukkoa aiemmassa tutkimuskirjallisuudessa: ensimmäinen koskee suurten puuviljelmien vaikutuksia paikallisyhteisöille (artikkelit I ja II); toinen eri instituutioita, jotka muovaavat viljelmien poliittista hallintaa (artikkelit III ja IV). Se myös esittelee tutkimuksessa sovellettavan viitekehyksen, joka yhdistää ja jäsentää keskeisiä yhteiskunnallisen ympäristötutkimuksen käsitteitä systeemiekologiasta sosiologiaan. Osatutkimuksissa on hyödynnetty sekä laadullisia että määrällisiä tutkimusmenetelmiä.

Artikkeli I esittelee systemaattisen kirjallisuuskatsauksen suurten puuviljelmien paikallisista sosioekonomisista vaikutuksista. Katsaus osoittaa, että vaikutusten juuret liittyvät usein maan hankintaan viljelmien pystyttämiseksi ja tästä seuraavaan paikallisten elinkeinojen menetykseen. Viljelmät ovat usein aiheuttaneet enemmän elinkeinojen menetyksiä kuin luoneet uutta työtä. Artikkeli I myös tunnistaa olennaisia aukkoja näitä vaikutuksia käsittelevässä tutkimuskirjallisuudessa. Artikkeli II soveltaa palautumiskyvyn (nk. resilienssi) käsitettä ja sisällönanalyysiä analysoidessaan uruguaylaisten mehiläishoitajien kokemuksia ja käsityksiä maankäytön muutoksista plantaaseiksi ja niihin sopeutumisesta. Tulokset osoittavat, että yhteisö kokee nämä muutokset useina toisiinsa kytkeytyvinä haasteina (esim. romahtaneet hunajasadot ja nousseet kustannukset), joihin heillä on yleisesti ottaen rajallinen kyky vastata.

Artikkelit III ja IV rakentuvat samalle Etelä-Afrikan puuviljelmäpolitiikkaa käsittelevälle aineistolle. Poliittisille uskomuksille pohjaava analyysi artikkelissa III tunnistaa kaksi kilpailevaa eturyhmäkoalitiota: hallitsevan *tavalliseen tapaan* -koalition ja sen haastavan *oikeudenmukaisuus ja muutos* -vähemmistökoalition. Artikkeli III myös selkeyttää politiikkainstrumentteja koskevien uskomusten roolia koalitionmuodostuksessa. Artikkeli IV puolestaan keskittyy poliittiseen oppimiseen – tiedon keruuseen ja jakamiseen erityyppistä tietoutta omaavien toimijoiden kesken. Se testaa tiedonvaihtoon liittyviä hypoteeseja ja osoittaa, että toimijoille on tyypillistä vaihtaa tietoa ja luoda luottamusta samoin ajattelevien kesken. Tulokset kuitenkin tukevat ajatusta, että poliittisiin foorumeihin osallistuminen mahdollistaa toimijoiden poliittisen oppimisen.

Suuret puuviljelmät ovat usein aiheuttaneet kielteisiä vaikutuksia paikallisyhteisöille. Kontekstilla (esim. maankäyttöoikeudet) on kuitenkin iso merkitys vaikutusten luonteelle. Vaikutukset ovat monella tapaa seurausta poliittisesta hallinnasta, jonka dynamiikkaa voi ymmärtää paremmin koalitionmuodostuksen ja poliittisen oppimisen kautta.

Asiasanat

Ekosysteemipalvelut; Eturyhmäkoalitiot; Poliittinen oppiminen; Sosiaalis-ekologiset järjestelmät; Uskomusjärjestelmät; Yhteiskunnallinen ympäristötutkimus

Acknowledgments

List of original articles

This doctoral dissertation consists of the following four articles, which are hereby referred to using their assigned Roman numerals, and the summary.

I. Arttu Malkamäki, Dalia D'Amato, Nicholas J. Hogarth, Markku Kanninen, Romain Pirard, Anne Toppinen, and Wen Zhou (2018). A systematic review of the socio-economic impacts of large-scale tree plantations, worldwide. *Global Environmental Change, 53, 90–103. https://doi.org/10.1016/j.gloenvcha.2018.09.001*

II. Arttu Malkamäki, Anne Toppinen, and Markku Kanninen (2016). Impacts of land use and land use changes on the resilience of beekeeping in Uruguay. *Forest Policy and Economics, 70, 113–123. https://doi.org/10.1016/j.forpol.2016.06.002*

III. Arttu Malkamäki, Tuomas Ylä-Anttila, Maria Brockhaus, Anne Toppinen, and Paul M. Wagner (20XX). Unity in diversity? When advocacy coalitions and policy beliefs grow trees in South Africa. *Submitted manuscript.*

IV. Arttu Malkamäki, Paul M. Wagner, Maria Brockhaus, Anne Toppinen, and Tuomas Ylä-Anttila (2019). On the acoustics of policy learning: can co-participation in policy forums break up echo chambers? *Policy Studies Journal (accepted for publication).*

Division of labour in co-authored articles

	I	II	III	IV
Concept and design	AM, AT, DD, MK, NH, RP, WZ	AM, AT, MK	AM, TYA, MB, AT, PW	AM, PW, MB, AT, TYA
Data collection	AM, AT, DD, MK, NH, RP, WZ	AM	AM	AM
Data analysis	AM, AT, DD, MK, NH, RP, WZ	AM	AM	AM
Writing manuscript	AM, AT, DD, MK, NH, RP, WZ	AM, AT, MK	AM, TYA, MB, AT, PW	AM, PW, MB, AT, TYA
Overall responsibility	AM, MK	AM	AM	AM

AM – Arttu Malkamäki, AT – Anne Toppinen, DD – Dalia D'Amato, MB – Maria Brockhaus, MK – Markku Kanninen, NH – Nicholas J. Hogarth, PW – Paul M. Wagner, RP – Romain Pirard, TYA – Tuomas Ylä-Anttila, WZ – Wen Zhou

Contents

1. Motivation

Humans ultimately depend on healthy ecological systems –ecosystems– for their well-being (Berkes and Folke 1998). The relationship between ecosystems and increasingly global social systems, however, is more complex and problematic today than ever before in recorded history (Biermann et al. 2012; Cardinale et al. 2012). The currently dominant view of the environment thus builds on an ontological structure where social (i.e., actors and institutions) and ecological (i.e., nature) dynamics interact within and across spatial, temporal, and administrative scales (Verburg et al. 2016). The interactions in such *social-ecological systems* trigger both slow and predictable as well as fast and unpredictable feedbacks, which have dramatically increased our collective exposure to major risks (Centeno et al. 2015; Rocha et al. 2018).

All ecosystems are subjects of gradual change due to climate variation, habitat fragmentation, nutrient loading, and biotic exploitation (Scheffer et al. 2001). Since the industrial revolution, however, both the human population and the enterprises that organised production in the capitalist format have grown considerably in size; a change that has been referred to as the *great acceleration* (Steffen et al. 2015). The continuous acceleration, however, has come into contradiction with the essentially finite funds of the natural capital that support life on Earth and contribute to human well-being.

The pace and magnitude of land cover (i.e., attributes of terrestrial ecosystems) and land use (i.e., human purposes applied to those attributes) changes over the last three centuries are unprecedented (Goldewijk and Ramankutty 2004). Since 1982, 60% of land cover changes have been linked to direct human drivers; the remainder with indirect human drivers, which includes the human-induced global warming (Song et al. 2018). The trade-offs of those changes are evident. For example, the average annual social cost of tropical deforestation alone has been *estimated* at 550 billion dollars (int.) between 2000 and 2012 (Song 2018).

More generally, changes in tree cover constitute one of the causes and consequences of environmental change. Globally, tree cover has increased by 7% in the past 25 years (Song et al. 2018). Increases concentrate in China and India, which have engineered ambitious programmes to conserve and expand tree cover while enhancing efficiency in food production (Chen et al. 2019). This dynamics follows Mather's (1992) notion of the *forest transition* in that industrialisation and urbanisation have promoted the expansion of tree cover in areas with high crop yields, low cultivator densities, and recent histories of extensive deforestation.

However, Rudel et al. (2016) suggest that there is also another dynamics that resembles Schnaiberg's (1980) notion of the *treadmill of production*. Increasingly over the past four decades, areas with humid climates have been passing through rapid cycles of planting, harvesting, and replanting of fast-growing trees in large-scale plantations. Consistent rationalisation of production and investments in technology have made it possible. Well-capitalised public and private enterprises have shifted from extracting wood from frontier forests to mass producing it through extensive human intervention (Boyd et al. 2001; Rudel et al. 2016).

However, defining such plantations universally is challenging; they are established under varying institutional and ecological conditions (D'Amato et al. 2017). My definition, which is in line with that of Kröger (2014), focuses on agency and power. I refer to them as non-edible trees cultivated in continuous large-scale units, established and *controlled* by public or private enterprises that come from outside the local context. Their physical extent can vary from hundreds to hundreds of thousands of hectares.

A persistent argument in favour of large-scale tree plantations is their alleged ability to take economic pressure off natural forests (Liu et al. 2018; Ghazoul et al. 2019). However, plantations may only have reduced forest degradation, potentially increasing deforestation either directly through displacement or indirectly through reduced value of forests leading to their conversion (Pirard et al. 2016; Curtis et al. 2018). In so doing, plantations may impose trade-offs to human communities that disproportionately rely on forests or other natural ecosystems for their well-being (Angelsen et al. 2014; Howe et al. 2014).

Despite the attributes of the existing ecosystem, plantation establishment tends to change its structure and functioning (Lindenmayer et al. 2015). Consequent changes in institutions, including those that used to govern access to land and livelihoods, have frequently sparked conflicts between the parties, sometimes involving authorities and social movements (Gerber 2011; Schirmer et al. 2015). Previous reviews of the impacts for exposed communities also highlight the precarious employment opportunities on plantations and displacement of communities due to plantation establishment (Cossalter and Pye-Smith 2003; Charnley 2005). Nonetheless, systematic evaluations of these changes and their consequences for local communities, whether positive or negative, and across diverse contexts, have been missing.

One could argue that production (here, physical inputs to physical outputs), rather than consumption (here, *using up* of resources), is the locus at which one can observe changes in ecosystems and social systems and address related problems. However, the complexity, uncertainty, and power asymmetries inherent to social-ecological systems challenge the capacity of governance to shape institutions and steer actors (Duit et al. 2010; Defries and Nagendra 2017). Governance, then, is the social function focused on steering actors toward mutually beneficial outcomes and away from mutually harmful outcomes (Brondizio et al. 2009). Much of governance that deals with social-ecological systems, however, occurs within a *complex institutional system* that may address many interlinked policy problems within a geographical area simultaneously (Lubell 2013).

Furthermore, some of the most pressing and persistent social-ecological problems are difficult to solve not only because of conflicting beliefs about causation of problems and disagreement over preferences about outcomes (Thompson and Tuden 1987; Defries and Nagendra 2017), but transaction costs, power asymmetries, and biases that govern actors' behaviour (Berardo and Lubell 2016; Boonstra 2016). For example, actors tend to order their belief system hierarchically and form coalitions with those whose policy beliefs are similar to their own to gain influence, win competing coalitions, and translate their beliefs into policy (Sabatier 1988; Weible et al. 2019). The so-called echo chamber effects, which refer to the actors' tendency to circulate information among those who think alike (Jasny et al. 2015), may reinforce these phenomena.

One way of overcoming such impediments to crafting consensus and addressing problems calls for social learning that *may* lead to more meaningful collective action (Koontz et al. 2015). The foci of such learning could be policy forums (Gerlak et al. 2018; Reed et al. 2018); yet, research on their role for governing actors' behaviour in diverse contexts has yielded somewhat inconsistent findings (Leifeld and Schneider 2012; Hamilton and Lubell 2018; Wagner and Ylä-Anttila 2018). However, our understanding of these and other factors that may either foster or impede actors from solving problems under conflict remains limited, particularly in governance systems devoted to large-scale tree plantations (Leys and Vanclay 2011).

In this dissertation, I synthesise four years of academic work by presenting findings from four scientific articles that demonstrate diversity in their respective methodological approaches. I take on the task of filling two gaps in the literature: the first concerning the human impacts of large-scale tree plantations (articles I and II); the second concerning the governance of such plantations (articles III and IV). I bring the articles together under a more general framework for empirical analysis. It combines and structures concepts and reasoning from research in systems ecology, institutional economics, political science, and sociology. Before further discussing the promises and perils of governance in addressing social-ecological problems, it describes ecosystems, social systems, and how they may change to produce impacts on human well-being. Finally, I apply the framework to the context of large-scale tree plantations.

Through the four articles, my objective in this dissertation is to answer two somewhat distinct questions that together form an explanatory account –*explanans*– of some highly controversial phenomena –*explanandum*– with respect to large-scale tree plantations:

1. How do the human impacts of land cover change to large-scale tree plantations manifest across local contexts (articles I and II)?

2. Which factors foster or impede actors involved in the governance of large-scale tree plantations to address problems under conflict (articles III and IV)?

The broad goal of this dissertation is to contribute to the quest for understanding feedbacks in social-ecological systems and identify conditions and actions that help us to understand and address controversies concerning our problematic relationship with nature. In so doing, this dissertation potentially informs policy and practice in grasping one of the less harmful pathways in the face of unprecedented pressures on land (Popp et al. 2017).

This dissertation summary is organised as follows. I start by describing the components of the proposed framework for empirical analysis and situating the respective contributions of the four articles within it. Next, I outline the methodological choices and main findings from each article. I conclude by summarising contributions, discussing limitations, and proposing ways forward.

2. Framework for empirical analysis

2.1. Conceptualising environmental change

The foundation for social-ecological systems as a conceptualisation of the environment lays in theories of complex adaptive (ecological) systems, which emphasise nonlinear progression, uncertainty of outcome, adaptive management, and search for system stability (Preiser et al. 2018). The search for stability of social systems also has long traditions in political science and sociology, namely through Parsons' (1952), Easton's (1967), and Luhmann's (1995) works. However, such searches for stability have largely failed to explain changes faced by societies and advance those changes that one might consider urgent to address sustainability challenges. The idea of social-ecological systems has thus emerged as an avenue for integrating ideas and reasoning from different disciplinary backgrounds to understand and navigate *environmental change*.

Ecosystems are composed of spatial and temporal interactions between numerous species across the trophic spectrum (Levin 1999). Ecologists have shown how ecosystems support life through biodiversity (i.e., species turnover plus food chain plus microbial diversity), changes in which tend to cause major changes in ecosystem functioning (Collinge 1996; Hooper et al. 2012). However, strict delineations between social and ecological dynamics are always artificial. Like ecosystems, social systems exhibit cross-scale interactions. Social systems, however, possess abilities to alter these interactions; humans tend to make forward-looking decisions, create and respond to abstract perceptions that shape their expectations, and develop technologies with far-reaching implications (Gibson et al. 2000). Social systems are composed of such interactions between actors and institutions that tend to evolve complex and trigger cross-scale feedbacks in social-ecological systems. For example, global warming and biodiversity loss are feedbacks to past human behaviour that concentrated in the northern hemisphere; yet, both currently shape our societies and affect our behaviour globally (Cardinale et al. 2012; Coumou and Rahmstorf 2012). These two systems have usually evolved together and are tightly coupled, even over long distances (i.e., *telecoupling*), through two mechanisms: press-pulse dynamics and ecosystem services (Collins et al. 2011; Liu et al. 2015).

Some routine changes such as seasonal species succession and housing prices are reasonably predictable and manageable processes; however, they rather occur within than across ecosystems and social systems, respectively. Other changes, including changes in land cover, are spatially extensive and permeate social-ecological systems for extended periods. Such relatively predictable and cumulative changes are pressures (Collins et al. 2011). Pressures, then, interact with more surprising and abrupt pulses (Gordon et al. 2008); for example, storms, floods, droughts, wildfires, and disease outbreaks. Understanding dynamics within and across pressures and pulses –press-pulse dynamics– is important for understanding the true character of environmental problems. Rocha et al. (2018), for example, recently estimated that 45% of all potential environmental collapses interact by amplifying one another.

Press-pulse dynamics may change the ecosystem structure. If ecosystem functioning changes due to changes in ecosystem structure, changes in provision of ecosystem services tend to follow. Ecosystem services refer to the multiple benefits that humans

derive from ecosystems (Westman 1977; Fisher et al. 2009). The concept implies a utilitarian framing of nature, emphasising the degree to which humans rely on healthy ecosystems for their well-being. It does not deny or exclude the intrinsic value of nature, although the human-centred concept of a service implies that there must be a beneficiary to assign value to it. Value is created and circulated in the co-ordination process between ecosystems and social systems, which may require varying degrees of human input (Wunder 2015; Matthies et al. 2016).

Ecosystem services, or service offerings to be exact, can be classified according to their type (Fisher et al. 2009); whether provisioning (i.e., tangible benefits that people derive from ecosystems), cultural (i.e., intangible benefits that people derive from ecosystems), regulating (i.e., benefits derived from regulation of ecosystem functioning), or supporting (i.e., services that enable other ecosystem services). They derive from the *funds* of natural capital, the trading of which rarely occurs in markets. Linking ecosystem services to applicable property regimes is thus necessary. To do so, one may turn to the typology of goods by Ostrom and Ostrom (1977) that classifies property regimes according to the combination of excludability (how difficult it is to exclude others from using that good) and subtractability (how much of that good is left after its use). This classification yields four types of goods: public goods, private goods, toll goods, and common-pool resources.

Most ecosystem services are declining for (at least) two reasons (Lant et al. 2008): first, because of the overconsumption of common-pool resources (low excludability and high subtractability); second, because of the strong economic incentives that encourage the development of funds of natural capital on private lands for marketable commodities at the expense of other ecosystem services that benefit the society at large. This leads to the so-called *tragedy of ecosystem services*, which seems difficult to remedy without passing major legal and economic reforms. In addition, the uneven allocation of ecosystem services and unjust access to them carry moral implications for their governance (Lehmann et al. 2018).

Another key concept for understanding dynamic social-ecological systems is resilience, which Holling (1973) coined to refer to the capacity of an ecosystem to counter and persist disturbances. Contemporary resilience, however, is more about the ability of societies, communities, and cultures to *adapt* and *transform* with change in constantly changing social-ecological systems (Folke 2016). Adaptability refers to the capacity of the system to influence resilience; transformability to its capacity to create a novel system if the existing one becomes untenable (Walker et al. 2004). A threshold (or a tipping point), in turn, can be used to conceptually indicate the breakpoint between two alternate stable states, the crossover of which implies passing *a point of no return* (Renaud et al. 2010). The concepts presented in this subchapter, particularly those concerning ecosystem services and resilience, are relevant for the articles I and II of this dissertation.

2.2. Governing environmental change

Global changes emerge from local changes in social-ecological systems, while global changes, in turn, cause local changes – that is, most attempts to manage them must be deployed locally (Cash et al. 2006). Frameworks that focus on producing knowledge about ecosystems and their value for humans often assume that changes in values

directly filter arguments into policy and practice (Spangenberg et al. 2014; Primmer et al. 2015). The causal multiplicity (i.e., feedbacks) of social-ecological systems and the almost endless spectrum of mechanisms for coping with change and addressing problems (e.g., existing social injustices), however, pose fundamental challenges to actors and institutions charged with the task of governing them (Duit et al. 2010). This suggests that our problematic relationship with ecosystems is not necessarily due to problems in management (i.e., developing and implementing means to achieve pre-determined ends), but failures in governance (Pahl-Wostl 2009).

The notion of government and division of actors between those who govern and those who to govern is severely outdated. Governance can be conceptualised within the realms of politics (i.e., translation of interests to collective action and policy, e.g., Sabatier 1988), polity (i.e., rules that govern actors' actions, e.g., Ostrom 2005), and policy (i.e., forms of political steering, e.g., Lascoumes and Le Gales 2007). Such divisions, however, do not necessarily make justice to the characteristics of social-ecological systems. For example, politics and polity, on which I hereby focus, are largely inseparable in empirical terms. Analysing these two realms of governance in empirical terms, however, requires one to study the actors, institutions, and the factors that foster or impede their capacity to adapt and transform with change and address problems in constantly changing social-ecological systems.

Social systems are crowded with multiple actors, both individuals and collectives, at multiple levels. In modern societies, however, collectives, rather than individuals, stand in the foreground (Knoke et al. 1996). In the context of globalisation, the influence of sovereign nations has also diminished (Hirst and Thompson 1995). Diverse non-state actors have emerged to occupy at least some of this space. These actors include social movements, community-based organisations, and civil society organisations. However, having a more formal organisational structure can also be a requirement for accessing governance, which many communities that may be living the impacts of environmental change to the fullest may not have (Fabricius et al. 2007). Besides state and non-state actors, private actors increasingly take part in governing social-ecological systems (Lockie 2013). I hereby refer to all actors that are directly or indirectly, formally or informally, affiliated with or affected by governance at any stage as *policy actors*.

Widening participation in this way is not meant to undermine representative democracy – rather, it reflects the need for governance in itself to adapt to deal with uncertainty and conflicts among actors (Tengö et al. 2014; Defries and Nagendra 2017). A complication is that actors take part in designing the *institutions* that *de facto* govern their own behaviour. Institutions are clearly defined as the formal and informal rules that govern the behaviour of actors in society (Crawford and Ostrom 1995). To articulate the division between formal and informal, one may turn to Scott's (2014) three pillars: regulative, normative, and cultural-cognitive institutions.

Regulative institutions refer to formal legal frameworks and formalised codes of conduct and practice. Introducing regulative institutions is relatively costly, while broadening their interpretation through formal negotiations and agreements will most likely be the preferred option for changing them. *Normative institutions* are identified within the informal norms in society. They are shared rules that are usually not coded anywhere and reflect the values held in communities and societies. The changes in normative

institutions tend to be more emergent and gradual than in regulative institutions. *Cultural-cognitive institutions* manifest as paradigms and beliefs, mental models, that influence, for example, how actors perceive the problems and what is the range of possible solutions to them. Institutional arrangements, such as social networks and organisations, are interlinked institutions of a higher order (Scott 2014).

The governance of industrial-scale production, however, has often evolved over time with significant financial, technological, and physical input (Gould et al. 2008; Köhler et al. 2019). Such evolutionary trajectories have also created self-reinforcing cultural-cognitive institutions (e.g., beliefs about causation of problems) that may have been useful in enhancing stability and convergence of actors' expectations. An absence of stability and predictability would lead to the inability of actors to develop expectations, correct errors in routines and practices, and solve problems of collective action. The problem of collective action, for example, is a fundamental one; unless solved or controlled, the transaction costs of organising activities in society easily become unbearable (North 1990).

With stability may come high resilience –great capacity to counter disturbances and persist– but also *rigidity traps* that impede institutions from adapting and addressing problems. For example, institutions that persist beyond the point where they are creative and adaptive can prolong the negative effects on ecosystems, which can, in turn, reduce the resilience of ecosystems (Holling et al. 2002). A *lock-in effect* is a similar term, which emerged in economics to refer to the persistency of established technologies despite their inferior performance (Pierson 2000). Especially the governance of industrial-scale production processes that have been moulded in past power struggles and required considerable investments in fixed capital, have frequently been found to be informed by informal guiding principles (i.e., cultural-cognitive institutions) that may not be widely open to consider alternative views (Geels and Schot 2007; Pahl-Wostl 2007). Participation by different actors in designing institutions bears potential for overcoming rigidity traps – however, other issues tend to emerge as part of such processes.

Somewhat analogous to complex *adaptive* systems, a contemporary view on governing social-ecological systems considers the polycentric configurations of actors and institutions –complex *institutional* systems– that formulate policy within a geographical area (Lubell 2013; Berardo and Lubell 2019). Polycentricity implies modular systems with many rule-based governance units, each of which may have a different purpose, organisation, and physical location. Decisions made in different units tend to be interdependent, yet authority to make decisions does not necessarily reside in any single unit. Policy actors may be willing to participate in several of them to increase their chances of achieving their policy goals, which may include a mix of altruistic and self-interested motivations. In other words, actors order their norm-based informal interactions under a framework of formal rules, which is how the system becomes self-organising. Redundancy is a feature of polycentricity, which reduces efficiency (Imhof et al. 2005), but may, for example, facilitate the spread of information and mitigate risks on account of redundant actors and institutions (Carlisle and Gruby 2017). Complex institutional systems display both routine practices and divisive disputes, often addressing multiple public good and common-pool resource problems simultaneously. Importantly, they set the *policy context* for governing social-ecological systems (Lubell 2013).

What remains of decades of searching for universal solutions –panaceas– for governing social-ecological systems is that their sustainability relies on the fit between the institutions, the context in which they operate, and the nature of problems that they are supposed to address (Epstein et al. 2015). Policy change to improve fit in complex institutional systems can emerge through a combination of meaningful collective action and emergent phenomena arising from the interactions between a range of actors with varying levels of influence, resources, and policy goals.

Because of the very nature of problems, however, conflicts are a frequent sight in the governance of social-ecological systems. Many social-ecological problems, namely those concerning trade-offs between ecosystem services, tend to be *wicked* problems, which results, in part, from the inability of actors to foresee all consequences of their decisions across the different scales (Defries and Nagendra 2017). In lack of an unequivocal sense of social purpose or single, unified policy goal in contemporary societies, actors operate in increasingly ambiguous contexts. Such contexts tend to be composed of numerous, often contradictory demands (Stirling 2003). Policy actors may have both conflicting beliefs about causation of problems and simultaneously disagree over their normative preferences about policy outcomes (Thompson and Tuden 1987). In contexts dealing with social-ecological systems, drawing of system boundaries can already be a subject of conflict (Lockie 2013).

By learning from one another and building consensus, actors who participate in governing social-ecological systems may potentially overcome ambiguity and conflict (Baird et al. 2018; Gerlak et al. 2018). Such social learning is thus one way of conceptualising how institutions can adapt to better fit the context and any given set of problems (Lebel et al. 2013). There are many definitions and applications of social learning in social-ecological governance (Ison et al. 2013) – I focus on *policy learning*. It can be described as the process of gathering, translating, and disseminating information between policy actors with diverse bases of knowledge (Heikkila and Gerlak 2013). One may further distinguish between three types of policy learning: cognitive, normative, and relational. *Cognitive learning* refers to knowledge gains; *normative learning* to a change in cultural-cognitive institutions; and *relational learning* to improved relations through, for example, accumulation of trust (Baird et al. 2014).

In practice, policy learning occurs in steps along the policy process that Henry (2017) divides in three: synthesising of information, solving of problems, and reaching of consensus. Learning, then, iteratively feeds back to the process as changes in institutions. In other words, the different types of learning are salient outcomes of institutional arrangements, in which actors are presented with new ideas and engage in deliberation with knowledgeable others from different backgrounds (Siddiki et al. 2017). Policy learning, then, designates the cognitive and social dynamics that either challenge or reinforce the cultural-cognitive institutions that govern the behaviour of policy actors (Moyson and Scholten 2018).

Learning must not be mistaken for its possibly linear progression toward *more sustainable* behaviour (Reed et al. 2010). If actors constantly revise and recast institutions, learning may also become somewhat haphazard. Of greater concern, however, is the absence of critical self-reflection that makes learning nearly impossible (Pahl-Wostl 2009). Such lack has been attributed to potential biases in reasoning and

behaviour of policy actors. They also tend to operate simultaneously; yet, somewhat differently in different policy contexts (Berardo and Lubell 2016). I hereby focus on two phenomena: the hierarchical structure of the belief system and the echo chamber effects.

A focal component of Sabatier's (1988) Advocacy Coalition Framework (ACF) is its three-tiered belief system, within which policy actors order their beliefs hierarchically. At the top, deep core beliefs are fundamental ontological beliefs and unlikely to change, but usually too general to guide policy (e.g., understanding of the relationship between human and nature). In the middle, policy core beliefs, be they normative or empirical, are more specific to the policy context, but still resistant to change (e.g., understanding of the desired balance between the market and the state). Change in policy core beliefs may occur if experience reveals significant anomalies in them. At the bottom, secondary beliefs relate to the implementation of policy and are the least resistant to change (e.g., when actors learn about the effects of economic incentives).

The ACF asserts that policy core beliefs constrain secondary beliefs lower in the belief hierarchy (Peffley and Hurwitz 1985), and if raised regularly in the policy debate, make the strongest contribution to the formation of advocacy coalitions. Advocacy coalitions may contain policy actors from a variety of backgrounds who share similar belief systems and show a non-trivial degree of co-ordinated activity to achieve their policy goals. Coalitions then compete to code their beliefs into policy. In many ways, resulting policy is the translation of the dominant coalition's beliefs (Weible et al. 2019). In the ACF, policy change may follow normative policy learning – that is, changes in policy beliefs. A change in policy core beliefs implies a major policy change, whereas a change in secondary beliefs suggests a corrective, minor policy change (Jenkins-Smith et al. 2014). The ACF also identifies windows of opportunity within the broader policy process that may redistribute political resources and advance policy changes (e.g., following an environmental disaster or a constitutional reform).

Advocacy coalitions, however, tend to become self-reinforcing. For example, policy actors operating in conflictual policy contexts may overestimate the malice and influence of their opponents. This may lead to distortion between coalitions, the extent of which may be a function of belief distance (Sabatier et al. 1987). Nonetheless, the so-called echo chamber effects offer an alternative, yet congruent, explanation for such distortion. Such effects refer to the tendency of policy actors to exchange information with those whose policy beliefs reinforce those of their own, systematically neglecting information from sources that contests or undermines them (Jasny et al. 2015). The term has become increasingly popular with the rise of digital platforms for communication in the public sphere (Colleoni et al. 2014). However, it is essentially a combination of known cognitive and selection biases (i.e., informal institutions): a tendency to interpret information in a way that confirms or reinforces one's existing beliefs (*biased assimilation*; Lord et al. 1979); the notion of similarity breeding connection (*homohily principle*; McPherson et al. 2001), and a tendency to form triadic configurations (*the friend of my friend is my friend*; Goodreau et al. 2009). Biased assimilation and the homophily principle create an *echo* (i.e., belief homophily); the tendency to close triads rather than leave them open creates the *chamber*, within which the echo is being circulated. Echo chamber effects tend to underlie coalition formation and form a major impediment to policy learning.

In addition, actors may intend to pool resources (e.g., finances, intelligence, personnel, and technology) to control or absorb uncertainty and further increase their own influence (Pfeffer and Salancik 1978; Hojnacki 1997). Direct co-ordination with influential actors can be costly in the sense that one must compete for attention with many others. Rendering additional benefits, one may reduce that burden by turning to influential actors who also think alike (D'Souza et al. 2007). Such behaviour could *amplify* the echo in the chamber, complementing, rather than challenging, policy beliefs. Influential actors, in turn, enjoy the luxury of being able to choose their preferred routes of communication and *orchestrate* the echo (Leifeld and Schneider 2012; Moeliono et al. 2014). In contexts with a high level of technical specificity, however, actors may have to co-ordinate with actors in charge of critical resources, regardless of their policy beliefs (Weible 2005).

One way to step outside coalition lines and overcome echo chamber effects, and thereby foster policy learning, is by organising policy forums (i.e., governance units). Forums have been variously described as collaborative institutions (Lubell 2004), advisory groups (Agrawala 1999), working groups (Klijn et al. 1995), policy committees (Leifeld and Schneider 2012), and bridging organisations (Crona and Parker 2012). Forums are organised for various reasons, yet they most typically bring together actors from different backgrounds, enabling them to gain knowledge from actors outside of their regular contacts (Fischer and Leifeld 2015). In line with Wagner and Ylä-Anttila (2018), I refer to them as any event or venue of advisory or public character that invites policy actors to exchange ideas, regardless of their longevity, frequency, or inclusiveness. By bringing together diverse actors and making the same information available to all participants, forums *enable* the emergence of a consensus. Forums thus enable all types of learning, whether cognitive (as knowledge gains), normative (as changed beliefs), or relational (as improved relations).

Policy actors may be willing to participate in forums to reduce the burden of transaction costs of influencing policy and gathering knowledge (North 1990). The expectation is that benefits of participation will outweigh its costs (Feiock 2013). To enable learning, however, forums must attract actors with diverse policy beliefs that challenge the existing paradigms, practices, taboos, and beliefs. Exclusion could also hamper the optimality and legitimacy of resulting policies, increasing the likelihood of resistance against their implementation (Reed et al. 2018). Because organising forums comes with the power to invite participants and set agendas, those perceived as neutral and legitimate by most policy actors are perhaps best positioned for undertaking such activities.

In forums that focus on governing social-ecological systems, policy actors that use ecosystems to produce private goods are likely to behave in ways that secure their own interests, rather than those of the public (Lockie 2013; McAllister et al. 2014) – that is, a reflection of the politics underlying the *tragedy of ecosystem services* (Lant et al. 2008). Hence, diversity alone rarely suffices to promote learning. The costs of participation can also climb too high for actors with fewer resources, which may further amplify the existing power asymmetries (Gallemore et al. 2015). Ospina and Saz-Carranza (2010) highlight the unity/diversity paradox: heterogeneity among participants often implies differences in resources and power that may compromise efficiency. The challenges start from differences in capacity to understand and harness professional language (O'Brien et al. 2013). However, the group dynamics in forums is not the focus of this framework. The

concepts presented in this subchapter, namely those concerning coalition formation and policy learning, are relevant for the articles III and IV of this dissertation, respectively.

2.3. Applying the framework to large-scale tree plantations

For the empirical analysis of the human impacts and governance of large-scale tree plantations, I use illustrative examples from relevant literature to apply the above concepts concerning environmental change and its governance to the context of large-scale tree plantations (Figure 1). There are eight components and their respective relationships: human behaviour, pressures, pulses, ecosystem structure, ecosystem functioning, ecosystem services, human impacts, and governance. I briefly outline the first five components, focusing on the last three that the four articles of this dissertation target. The examples are from different contexts; the framework is thus only applicable to large-scale tree plantations (as defined in the introduction) more generally.
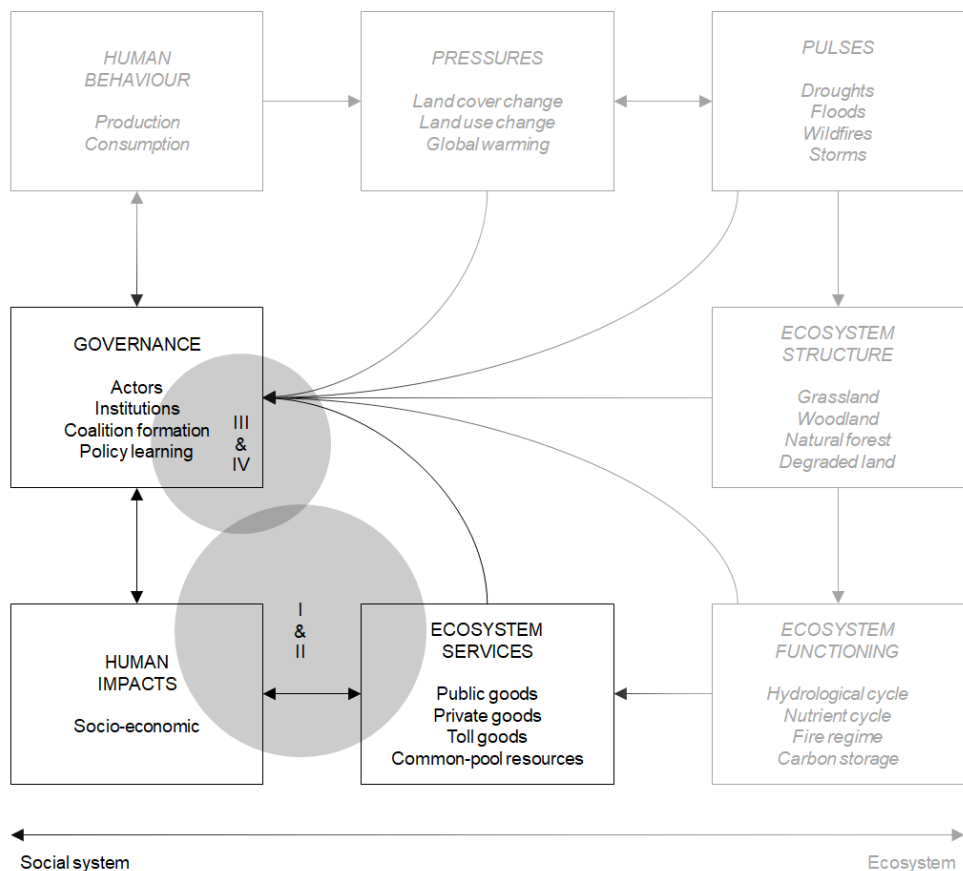
Figure 1. Framework for empirical analysis based on own elaboration; lines indicate the direction of effects; circles indicate the knowledge gaps and respective contributions of the four articles.

In the context of the *great acceleration* (Steffen et al. 2015), wood is increasingly produced in large-scale tree plantations through extensive human intervention (Boyd et al. 2001; Rudel et al. 2016). Areas with suitable climates are passing through rapid cycles of planting, growing, harvesting, and replanting of fast-growing trees; most

commonly, a species of *Acacia*, *Pinus*, or *Eucalyptus*. The metaphor of an out-of-doors assembly line –*an industrial treadmill of wood production*– thus captures the essence of large-scale tree plantations. Using trees to produce a range of commodities (e.g., pulp, carton, furniture, and energy) generate profits for producers. Sizeable investments of capital (e.g., technology) in lands and commodity chains have also allowed enterprises to expand production of commodities from the lands that they control (Rudel 2009). As in many other industries, such expansion may have lowered prices of commodities and reduced profits, which, in turn, may also have forced further expansion (Gould et al. 2008). The producers, rather than consumers, are thus the main force driving the **human behaviour** that causes changes across social-ecological systems. Globally, large-scale tree plantations cover around 1% of the tree cover (46 million hectares), producing around one-third of all wood (excluding fuelwood) that enters the markets (Barua et al. 2014; Payn et al. 2015).

Plantations are often established on grasslands and woodlands, although in some areas they have also displaced natural forests (van Holt et al. 2016; Curtis et al. 2018). They drive land cover and land use changes as relatively predictable and cumulative **pressures** that interact with more surprising and abrupt **pulses**. Global warming and possibly other factors may shape these pervasive dynamics (Coumou and Rahmstorf 2012). Press-pulse dynamics alter the structure and functioning of the previous ecosystem. The existing **ecosystem structures** (e.g., grassland) enable **ecosystem functioning**, the latter of which includes hydrological cycles, nutrient cycles, fire regimes, and carbon storages.

Plantations may alter ecosystems in many ways. Compared to natural or other types of forests, large-scale monocultures of genetically improved trees host much lower levels of soil fertility, carbon storage, and biodiversity (Liao et al. 2012; Veldman et al. 2015; Lewis et al. 2019). Compared to severely degraded lands, however, plantations can benefit the ecosystem (Brockerhoff et al. 2008). On seasonally dormant grasslands, plantations have tended to alter hydrological cycles, which is believed to occur due to the deep roots and evergreen canopies of the trees that cause evapotranspiration (Dye and Versfeld 2007; Silveira et al. 2016). These trees can also become invasive, which is facilitated by the rapid cycles of harvesting and dense networks of roads in plantations (Dodet and Collet 2012; van Wilgen and Richardson 2014). Structurally and compositionally uniform plantations with abundant fuel to burn and roads along which to spread are also more susceptible to wildfires than natural ecosystems (McWethy et al. 2018).

Regarding **ecosystem services**, plantations can undoubtedly supply vast amounts of private goods. In line with the *tragedy of ecosystem services* (Lant et al. 2008), such goods may come at the expense of public goods and common-pool resources (although plantations can also create them, e.g., Baral et al. 2016). The combination of changes in availability of and access to, for example, arable land, fresh water, fertile soil, and cultural heritage may cause direct or indirect, intentional or unintentional, socio-economic impacts for local communities. If negative, **human impacts** frequently feed back to the system through conflicts of varying intensity (Gerber 2011; Dhiaulhaq et al. 2014). Ecosystem services require varying degrees of co-ordination between ecosystems and social systems (e.g., labour to plant and harvest trees); the human impact is thus the

sum of changes in ecosystem services and human input. Trees may also be processed in the region, which usually increases the need for such input (Hassan 2003).

The processes of **governance** in the context of large-scale tree plantations encompass diverse policy contexts –complex institutional systems– that range from those in Australia to those in Mozambique (Rudel et al. 2016). A complication is that local communities manage an estimated 65% of the world's land cover under informal institutions (RRI 2015). In contrast, less than one-fifth of these lands are formally recognised; governments have claimed much of these lands under formal institutions, based on which they can, among other things, issue concessions to enterprises. The reallocation of *control* over these lands to governments, households, and enterprises has often created overlapping land claims, yet the communities living off these lands are particularly vulnerable in face of displacement and marginalisation (Fabricius et al. 2007; Villamayor-Tomás and García-López 2018). Investments in plantations also target these areas. Governance, then, can shape the institutions, provision of ecosystem services, and potentially the human impacts of plantations. It absorbs information from all other components of the framework, potentially feeding back to the system through changes in policy and practices. The Forest Stewardship Council (FSC) is an example of participatory governance in the context of plantations, which focuses on incentivising producers to follow voluntary sustainability standards (Eden 2009; Moog et al. 2015).

Finally, the framework depicts the contributions of the four articles to filling the two knowledge gaps: the first concerning the human impacts of large-scale tree plantations (articles I and II); the second concerning their governance (articles III and IV). Article I considers the relationship between the ecosystem services and the human impacts by reviewing all available literature concerning the socio-economic impacts of large-scale tree plantations for local communities across the globe. Article II extends this contribution by analysing the Uruguayan beekeeping community's experiences of and responses to a relatively rapid land cover change from grasslands to tree plantations. Article III makes use of the belief system of the ACF to analyse the advocacy coalitions and policy beliefs of policy actors in the context of South African tree plantation policy. Article IV stays in the same policy context, testing for the existence of echo chamber effects and whether co-participation in policy forums can break them up to enable policy learning.

The empirical link between the first and last two articles is thin. However, articles I and II highlight problems that are rooted in governance failures. The phenomena analysed in articles III and IV, in turn, can help to understand the forces that generate the impacts identified in articles I and II. This justifies the gentle overlap between the circles in Figure 1. Table 1 provides an overview of the four articles.

Table 1. Overview of the original articles.

	I	II	III	IV
Dissertation research question	How do the human impacts of land cover change to large-scale tree plantations manifest across local contexts?		Which factors foster or impede actors involved in the governance of large-scale tree plantations to address problems under conflict?	
Type	Review	Empirical	Empirical	Empirical
Article research question	What are the direct and indirect socio-economic impacts of large-scale tree plantations for exposed human communities in different contexts across the globe?	How Uruguayan beekeepers face and respond to the environmental change attributed to the establishment of large-scale tree plantations?	What advocacy coalitions can be identified in the context of South African tree plantation policy and how beliefs concerning policy instruments contribute to coalition formation?	Can co-participation in policy forums break up echo chamber effects and enable policy learning?
Lens	Theory-of-change and impacts of other types of large-scale land-based investments.	Community resilience and feedbacks to crossed and anticipated social-ecological thresholds.	Hierarchical belief system within the Advocacy Coalition Framework.	Echo chamber effects and policy learning.
Case	Worldwide	Uruguay	South Africa	South Africa
Data	Systematic literature search	Key informant interviews	Key informant interviews	Key informant interviews
Method	Qualitative meta-synthesis	Qualitative content analysis	Discourse network analysis	Exponential random graph modelling
Finding	Impacts are highly context specific. Clearly, trade-offs faced by locals are unbearable if they and/or their livelihoods have been displaced. Labour opportunities created by plantations tend to be sporadic and precarious. They can rarely compensate for the livelihood losses. However, evidence base is limited because of spatial and temporal biases and poor comparability of findings across empirical cases.	Beekeepers face land cover and land use changes as multiple challenges. Flowering patterns of vegetation have changed, which causes the main problem. The institution in terms of accessing vegetation has also changed. Many consider adaptation through migration or by changing occupation.	Two coalitions are formed based on congruence over policy core beliefs: a dominant business-as-usual coalition and a minority justice and change coalition. Coalition lines are confirmed by comparing the congruence network to an observed co-ordination network. Policy core beliefs constrain beliefs concerning policy instruments lower in the belief hierarchy.	The more the policy actors participate the same policy forums, the more likely they are to exchange information (cognitive learning) and trust their information exchange partners (relational learning). However, echo chamber effects are also in operation, meaning that they may still govern actors' behaviour within forums. Most actors participate only in a single forum.

3. Methodological choices and main findings

3.1. Articles I and II: the human impacts dimension

The articles I and II were designed to answer my first research question: *How do the human impacts of land cover change to large-scale tree plantations manifest across local contexts?* Article I reviews available case studies across literature. Article II constitutes one such case study and describes the human impacts of land cover and land use changes from the perspective of Uruguayan beekeepers. I briefly summarise the methodological choices and the main findings from these articles.

To understand the human impacts of large-scale tree plantations for local communities beyond individual case studies, we chose a systematic review approach for article I. Systematic reviews aim at identifying the most reliable *evidence* on specific questions by minimising selection biases in literature searches and screening processes. The method originates from the quest to evaluate findings from scattered clinical experiments in medicine and map the status of the evidence base. However, it is increasingly applied to inform the governance of social-ecological systems (Dicks et al. 2017).

Article I used an *a priori* review protocol, which defined the main components of the review framework (Malkamäki et al. 2017). This framework defined relevant populations of interest (local human communities), interventions to which the populations are exposed (plantation establishment), impacts of interest (direct or indirect changes to socio-economic status), evaluation of causality (temporal or spatial comparisons), and contextual factors that could explain differences in different contexts (attributes of the social-ecological system). Definitions were designed together with external researchers and stakeholders. They were operationalised in literature searches and the screening process with the aim of identifying all case studies from available white (i.e., books, book chapters, and journal articles) and grey (e.g., organisational reports, committee documents, and conference papers) literature.

In the beginning of each stage of the review, we tested our inter-reviewer consistency by conducting kappa tests with smaller subsets of studies (Brennan and Prediger 1981). Eventually, 111 studies met our inclusion criteria. We extracted data from them using a standardised data extraction sheet (see supplementary information). Its design was based on principles common to qualitative meta-synthesis, including the systematic coding of variables (Walsh and Downe 2005). We also came up with a quality evaluation tool to promote transparency (Bilotta et al. 2014). For a study to be included, it had to meet the baseline criterion of the main results being logically derived and based on presented data and methods.

This left us 92 studies with 105 individual case studies that were further divided in two groups based on additional criteria. Studies in group A presented a proper comparator (before/after or with/without plantation) and at least verbally considered factors that could have affected the validity of the findings; all other studies went to group B. The division was conducted to see whether the results between these groups would differ.

We identified socio-economic impacts that eventually fell under nine categories (Table 2). We had also theorised and eventually benchmarked these categories to our theory-

of-change in Malkamäki et al. (2017) and reviews of other large-scale land-based investments, including one by Hunsberger et al. (2017). The multidimensionality of some categories, their inevitable overlaps, and the methodological multiplicity of the identified case studies, however, added some complexity to the review.

Table 2. Definitions of the nine impact categories.

Land	Impacts caused by the process of land acquisition and its direct consequences, including changes in formal or customary access to land with or without compensation, concentration of land ownership, and changes to availability of and access to local food or fuel.
Employment	Impacts related to wage employment, including labour intensity, working conditions and the roles of outsourcing and migrant workers. Local processing and nurseries, which depend on the physical presence of the plantation, are included.
Livelihoods	Impacts on conditions for engaging in previous or other livelihood activities; not including cash income and wage employment.
Cash income	Impacts on monetary earnings at individual, household and community levels, and changes to income-based poverty levels.
Infrastructure	The delivery - or lack thereof - of roads, schools, clinics, electricity and water-related infrastructure.
Health	Impacts on health due to injury, pesticide usage, disease vector or change to nutritional status.
Cultural ecosystem services	Impacts on human well-being related to changes to ecosystem function that support recreation, traditions, aesthetics, identity and sense of place.
Regulating ecosystem services	Impacts on human well-being related to changes to ecosystem function in regulating water quantity and quality, soil fertility, shade, erosion and micro-climate.
Social	Impacts on social structure and interactions, including migration, demographics, equity, and tensions between actors.

Some studies did not provide a clear indication against a baseline or any other statement of the nature of impacts. In such cases, we made deliberative interpretations to characterise the change as predominantly positive, predominantly negative, mixed, or something else in a few cases. Of the 251 impacts, most fell under the categories of employment (22%), land (21%), social (20%), and livelihoods (12%). We recorded impacts most frequently in Southeast Asia (34%), South America (29%), and Africa (23%). Generally, case studies across groups A and B point toward negative impacts for local communities (Figure 2). Some of the categories, however, are inclined to record either negative or positive impacts (e.g., *land* being lost, or *infrastructure* being built), statistical comparisons between categories are not meaningful. Of the 81 associations between impact categories, 91% are identified as mutually reinforcing. For example, the impacts in the category social often act as feedbacks to impacts in categories employment, land, and livelihoods.
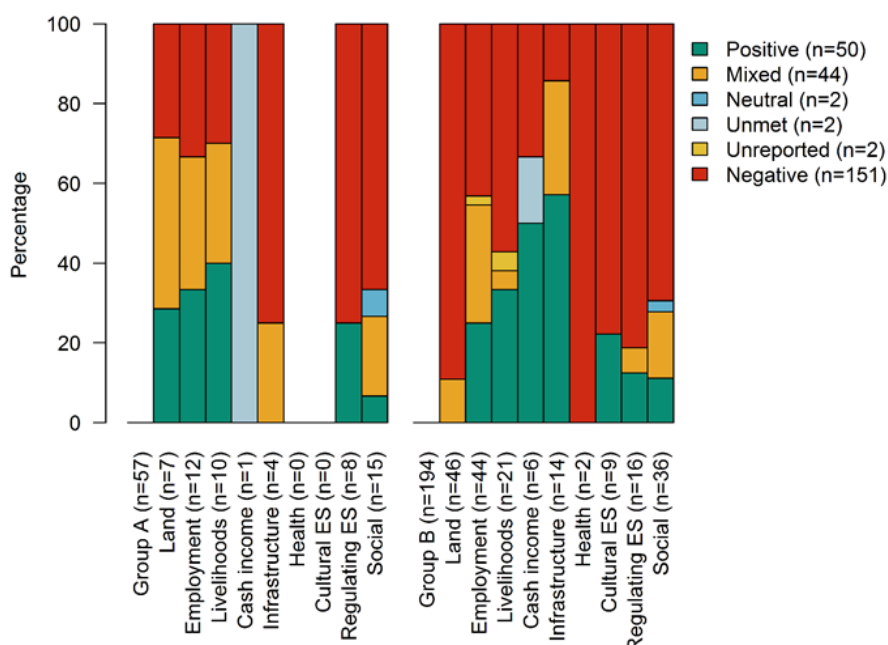
Figure 2. Share of impacts by group and category.

In the category *land*, 81% of impacts were characterised as predominantly negative; 79% of them were reported from Africa or Southeast Asia. Plantation establishment in the context of unclear land use rights has tended to cut or limit the access of communities to lands or forests with negligible compensations. Impacts in the category *employment* also told the story of negative impacts (i.e., jobs on plantations tend to be sporadic and part-time; yet, the presence of processing facilities and additional jobs seemed to correlate with more positive impacts. Based on the findings, wage employment on plantations does not constitute a living for many; at best, it may complement other livelihoods. The category *livelihoods* largely accompanies the category *land*. If access to lands or forests is lost, so are the (sometimes highly diverse) livelihoods that were based on those lands. However, the review shows that plantations can also create or promote novel livelihoods. These include the tapping of resin and rubber in pine and rubber plantations, respectively, and growing of trees on own lands to sell wood to the established commodity chain. However, these livelihoods may not be comparable to the ones that were lost. Impacts in the category *social* tend to interact with the other categories; conflicts of varying intensity are among the most common feedbacks to increased competition over jobs and land. In a few cases, participatory processes have been able to converge the views and expectations of the different actors. Nonetheless, more common are examples of the consequences of lacking rules and sanctions imposed on producers with respect to their failed promises, which have often worsened their relationships with the locals. These are examples of governance failures.

The review shows an increasing interest in the topic; however, many case studies have been conducted relatively recently after plantation establishment, potentially introducing a bias toward the category *land*. Research has also concentrated in some areas (e.g., in Chile and Cambodia). Some areas known to have undergone plantation development are underrepresented (e.g. Spain and Portugal). Quasi-experimental studies in the

positivist tradition have more frequently utilised comparators to explore causalities, leading to their higher frequency in group A. However, methods ranging from focus group discussions to household surveys have been used in both groups. Group A shows more mixed impacts than group B with much more case studies; group B much more negative impacts. The review also shows that case studies that draw the link from changes in ecosystem functioning to changes in the well-being of local communities are generally rare. However, article II makes an exception.

Article II goes into the details of one of the case studies reviewed in article I. It deals with the Uruguayan beekeeping community faced by major changes in their social-ecological system. Western Uruguay hosts a seasonally dormant shrub and grassland biome (Six et al. 2014), of which diverse vegetation has attracted beekeepers for many decades (Conforte et al. 2006). Applying the concepts of resilience and thresholds of social-ecological systems, article II analyses the consequences of the relatively rapid land cover changes to tree and soy plantations based on the experiences, perspectives, and responses of this community. The analysis made use of the concepts of resilience and thresholds of social-ecological systems.

We chose a qualitative approach to analyse complex phenomena and understand how the members of the beekeeping community perceive the social-ecological change and explain it through their subjective worldviews. We conducted semi-structured interviews with beekeepers and other relevant actors along the honey trail from Uruguay to Europe (see supplementary information). Such interviews allow flexibility in the course of the interview and are considered adequate for exploratory approaches (Creswell and Creswell 2019). We identified and contacted the key informants from contact directories and brochures, as well as based on the recommendations from the initial contacts.

The main concepts were operationalised by asking questions regarding recent trends and shocks, their causes, and the subsequent responses and recovery mechanisms. Other questions considered issues such as honey yields, price shifts, and changes in access to ecosystem services and other institutions. Specific questions to track or anticipate the positions of social-ecological thresholds could not be designated in advance, which is common to, and a common critique of, epistemologically challenging concepts such as the simultaneous dynamics of multiple thresholds (Christensen and Krogman 2012).

The analysis focused on validity and a thick description of the data, conscious that it might have come at the expense of reliability and generalisability of the findings. In line with the principles of qualitative content analysis (Miles and Huberman 1994), the interviews were transcribed, printed, and highlighters of different colours used to divide the themes that arose from the data into categories. A weakness of any qualitative approach is the risk of intentional or unintentional misrepresentation of information by the informants due to underlying motivations. Final interpretations were thus derived and verified by triangulating the analysed data with insights from literature, documents, and statistics concerning honey production.

The analysis shows that beekeepers experience the changes through displacement and crushing between the intensively managed soy and eucalypt plantations of a large scale. Both types of land cover change contribute to the displacement of the diverse vegetation

in the grasslands that would attract bees round summer; the season that used to be the most important for honey production. Soy and eucalypt also flower, meaning that bees may forage them. A species of eucalypt, *Eucalyptus grandis*, had provided important, yet sporadic, flowerings in autumns. An additional harvest of eucalypt honey had compensated the losses of other vegetation, but of which the beekeepers had become increasingly dependent. The biodiversity used to provide the bees with their nutrition to survive the winters. Now, beekeepers had to feed their bees artificially, which added costs to honey production. The access to vegetation, which used to be based on an informal exchange between pollination of neighbours' clovers, had become a subject of a formal contract between the beekeepers and the enterprises managing tree plantations.

Adaptability among the members of the beekeeping community varied. In areas with more soy plantations, beekeepers expressed their inability to continue with the livelihood or migrate to find better opportunities. Elsewhere, honey co-operatives had begun adapting through collective action to cut costs and voice concerns. Others were considering *transformation* by changing occupation or migrating to areas with fewer pressures on land. Fabricius et al. (2007) would most likely describe this community as a *powerless spectator* with a weak capacity to govern, few financial or technological options, and a lack of resources and networks. Some members of the community, however, may be described as *coping actors*, who demonstrate capacity to adapt without having a significant voice in the management of the ecosystem that determines the fate of their livelihood.

3.2. Articles III and IV: the governance dimension

The articles III and IV build on the notion that one may attribute some of the impacts of land use and land cover change to successes and failures in their governance. Both rely on the same data and the same empirical context of South African tree plantation policy to address my second research question: *What factors foster or impede actors involved in the governance of large-scale tree plantations to address problems under conflict?*

The policy context involves multiple policy actors from diverse backgrounds. Persistent sources of conflict are the effects of tree plantations on water and biodiversity, as well as their respective regulation (van Wilgen and Richardson 2012; Kruger and Bennett 2013). South Africa is simultaneously trying to redress the past injustices of racial discrimination and address widespread rural poverty without undermining the ability of the ecosystems to support current and future generations. Specific issues concern the (re)distribution of costs and benefits of land use, disagreement about the scientific validity of existing policies, and the broader questions of whether, how, and to what extent to reconcile economic, social, and ecological objectives (Goldin 2010; Bennett and Kruger 2013; Dye 2013; Witt 2014; Hall and Kepe 2017). The context has also been introduced with policy instruments; these include certification to the standards of the FSC and the addition of biodiversity and other ecosystem services to management objectives (Scotcher 2006; Samways and Pryke 2016). An indicative zoning for the establishment of plantations in the province of Eastern Cape has also been made in response to the shrinking tree cover (Government Gazette 2009; Government Gazette 2017).

Article III aims at identifying the coalitions in this turbulent policy context. In addition, it intends to clarify the roles that beliefs concerning specific policy instruments might play in coalition formation. The data for article III (and article IV) were collected from South Africa in 2017 through semi-structured interviews with 55 organisations. An initial *roster* of organisations was drafted based on publicly available information, which was then reviewed by three independent key informants. Based on their feedback, the *roster* eventually included 59 organisations. Four organisations either refused from being interviewed or could not participate. These four were also left out from all analyses.

The representatives of organisations were identified and contacted using contact directories and information of individuals received from the initial contacts. We ensured that each representative was in an executive position in their respective organisations. Such purposive sampling is effective when there is a need to interview knowledgeable experts (Tongco 2007). The representatives were asked to elaborate on their preferred vision for the future, how realistic they considered this vision, and what they thought were the barriers for its realisation and how to overcome them (see supplementary information). Other questions were related to the quality of the policy process.

Ideational alignment by is essentially a relational phenomenon and network analysis is best conceived as a methodological toolbox for relational analyses (Borgatti et al. 2009). They are also an important lens for operationalising and analysing governance in complex institutional systems (Scott and Ulibarri 2019). The transcribed interviews were coded in a software designed for Discourse Network Analysis (Leifeld 2010). It combines social network analysis with qualitative content analysis to create relational data by linking actors based on their congruence over beliefs (Leifeld 2017). Statements were coded under belief categories – that is, whenever an organisation made a claim that could be interpreted as a policy belief. Resulting congruence networks capture the essence of policy debates intuitively. They are thus rather straightforward operationalisations of advocacy coalitions (Leifeld and Haunss 2012). Successful coalitions can be expected to bundle a variety of different arguments in a broad, but still integrated, set of arguments; those less successful are more likely to keep on iterating the same limited set of arguments.

Of the 656 statements coded under 40 different belief categories, agreement and disagreement over three policy core beliefs and three beliefs concerning policy instruments were included in the analysis. These represented 33% of all statements. They were used to construct adjacency matrices for both types of beliefs. They equal to undirected and weighted networks, the ties in which reflect the strength of discursive association. Relational data were collected as part of the interviews by presenting the roster to the representatives, who were then asked to indicate whom they identify as information exchange partners, whether they exchange resources, whom they identify as especially influential, and whether they trust those organisations. Some of these data were collected for article IV, which also uses data on actors' participation in policy forums. For the analysis in article III, these data were used to construct another adjacency matrix of information exchange with trusted partners to represent a directed and binary co-ordination network to compare the congruence networks with.

In article III, Gephi software was used to perform network analysis (Bastian et al. 2009), in which coalitions were detected by maximising modularity (Newman 2006). We applied

the Louvain algorithm to measure how well the weighted matrices decompose into communities of densely connected nodes (Blondel et al. 2008). The modularity function can be modified by a tuneable resolution parameter, which in this case was fixed at 1.2 instead of the default 1.0 to facilitate the detection of larger communities representative of advocacy coalitions (Lambiotte et al. 2009).

The network visualisation on the left in Figure 4 shows how actors split into two coalitions based on policy core beliefs with more ties inside coalitions and fewer between them. Based on these results, we identify a dominant *business-as-usual* (BAU) coalition (64% of actors), of which ideas are challenged by a minority *justice and change* (JAC) coalition (36% of actors). We were able to validate this finding by comparing the composition of the coalitions to those detected in the co-ordination network in the middle of Figure 4. A qualitative analysis provides further support for the existence of these coalitions.
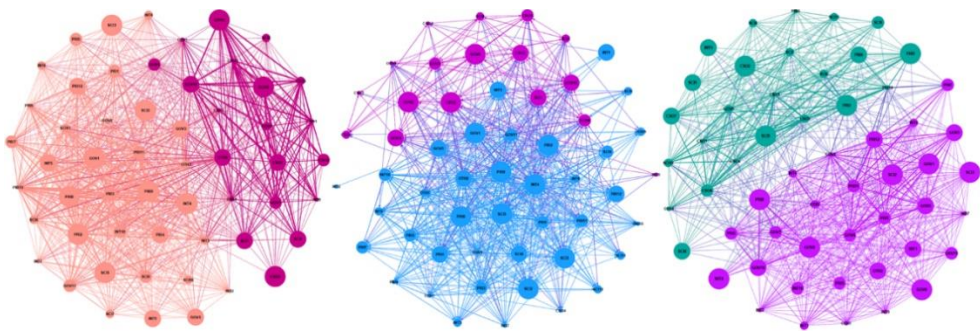
Figure 4. Modularity based on congruence over three policy core beliefs (left), observed co-ordination (middle), and congruence over three policy instrument beliefs (right). The size of the nodes indicates the number of times the organisation was voted as especially influential by the other 54 organisations: the larger the node, the higher the influence class.

The core actors inside both coalitions tend to agree on several of the three policy core beliefs and form stronger ties. The members of the BAU coalition are rather consistent in expressing their beliefs. Interestingly, yet unsurprisingly, enterprises, governments, and workers, all three of which have been found to keep the *treadmills of production* in place also in other policy contexts (Gronow and Ylä-Anttila 2016), are all members of the same coalition that defends the existing social order and prioritises economic values. The members of the JAC coalition are not entirely unified in their beliefs and underlying reasoning. Besides being the minority coalition, this further reduces this coalition's chances of influencing policy. The core of the coalition consists of civil society organisations and government departments in charge of implementing environmental regulation. This coalition questions the existence of the industry based on its social costs that are perceived to exceed its benefits.

Beliefs concerning policy instruments also divide actors into communities (visualisation on the right in Figure 4). However, after comparing the composition of these communities to the co-ordination network, and the arguments that actors use to articulate their policy position, we find that these beliefs do not contribute to coalition formation as such. Policy actors support the same instruments for various, often conflicting reasons that align with the actors' policy core beliefs higher in the belief hierarchy.

Because policy instruments found both support and resistance across coalition lines, article III suggests that beliefs concerning policy instruments could serve as bridges between them. The challenges faced by South Africa and this policy context are mounting, which might eventually force actors and ideas across coalitions to overcome past disputes and learn from one another to find solutions to the problems.

Setting out hypotheses regarding the behaviour of policy actors and estimating Exponential Random Graph Models (ERGMs), article IV, in turn, aims to clarify the role that co-participation in policy forums plays in enabling *cognitive* (knowledge gains) and *relational* (improved relations) policy learning. Due to its cross-sectional modelling approach, article IV is unable to analyse *normative* (changed beliefs) policy learning. The three hypotheses concern the roles of echo chambers (H1), resource pooling (H2), and co-participation in policy forums (H3) for the information exchange behaviour of policy actors:

H1 – *Policy actors tend to exchange information with those with policy beliefs that are more similar to their own*

H2 – *Policy actors tend to exchange information with those that have a reputation of being especially influential*

H3 – *The likelihood that policy actors exchange information increases as they participate in more of the same policy forums*

H1 arises from the notion of echo chamber effects in conflictual policy contexts; the implications of policies that would effectively address the problems in the context of South African tree plantation policy might encourage those in an influential position to defend their prior attitudes and actively challenge incongruent arguments without having to recognise the full scale and implications of problems. The cost of changing one's mind can also be high (Kirkebøen et al. 2013; Leach et al. 2014). H2 arises from the Resource Dependency Theory (RDT), which challenges the assumption of the ACF that shared policy beliefs explain most co-ordination between policy actors. The RDT views organisational resources (e.g., political influence) as the main determinants of co-ordination (Pfeffer and Salancik 1978; Stokman and Berveling 1998). Reputational influence, then, could be taken as a sign of high quality (Ingold and Leifeld 2016). H3 emerges from the promise of policy forums in enabling policy learning (Fischer and Leifeld 2015). Those who co-participate in more of the same forums are more likely to be aware of the existence of one another and the types of information they possess, increasing the likelihood of them recognising one another as information exchange partners.

ERGMs investigate both theoretical hypotheses regarding relational phenomena and their interactions to reproduce an observed network (Cranmer et al. 2017). Relational network data are non-independent, meaning that the probability of a tie between two actors might depend upon the structural properties of the network in which pairs of actors are embedded. Given the dependencies among observations, standard regression models would erroneously attribute explanatory power to exogenous variables – that is, standard errors would turn out being too small, error terms being correlated across observations, and p-values for exogenous variables being overly optimistic (Cranmer

and Desmarais 2011). ERGMs model the probability of a given configuration of the network, as compared to all other possible network configurations with the same number of nodes (size) and ties (density) in the network. Network structure is, then, modelled based on actor-level variables (node covariates), dyadic variables (edge covariates), and endogenous network structures (e.g., reciprocity and transitivity). The details of variables are described in article IV.

Methodologically (not detailed in article IV), ERGMs integrate an exponential family form log-likelihood function. Given the abundance of potential configurations, computing the exact maximum likelihood is too demanding (Cranmer et al. 2017). ERGMs usually rely on the Markov Chain Monte Carlo Maximum Likelihood Estimation (MCMC-MLE), which approximates the exact likelihood by relying on a sample from the range of possible networks to estimate the parameters. MCMC-MLE proceeds step-by-step by approximating the sum in the denominator of the likelihood function based on a series of networks sampled from the distribution parameterised with those parameters that maximised the likelihood with the previous sample. Optimisation goes on until the differences between the sufficient statistics of the observed network and the average of the sufficient statistics in the sample of simulated networks step outside the 95% confidence interval (Cranmer and Desmarais 2011).

Article IV starts by analysing how the actors with different beliefs may have encountered one another in forums. It finds that actors with beliefs that span nearly the full breadth of all beliefs have several opportunities to meet. While some actors participate in almost every forum, rural communities, being largely absent from the entire network, are also absent from all forums. Forums in operation might thus be failing in bringing forward potentially relevant perspectives and heuristics to formulate contextually appropriate policies that would effectively address problems.

The modelling results, in turn, indicate that all three of our hypotheses hold for both information exchange and information exchange with trusted partners (Table 4). Model A tests the three hypotheses using the existence of ties in the information exchange network as the dependent variable. Model B does the same using the trusted information exchange network as the dependent variable. The measures for goodness-of-fit indicate satisfactory fit for both models. These findings support the idea that actors indeed tend to exchange information (and build trust accordingly) with those who think alike (there is an *echo* and the *chamber*), while they also tend to exchange information with those who have a reputation of being influential. Nonetheless, those who co-participate in more of the same forums are also more likely to exchange information (and build trust) than expected by chance. We also used several control variables to ensure that we are not erroneously attributing explanatory power to the variables that test our hypotheses.

Table 4. Results for the ERGMs with standard errors in parentheses.

	Model A	Model B
	Information exchange network	Trusted information exchange network
	Information acquisition aspect of cognitive learning	*Trust accumulation aspect of relational learning*
	Density = 0.40	Density = 0.27
Edges	-4.28 (0.47) ***	-3.12 (0.29) ***
Exogenous variables		
Belief homophily (H1)	0.08 (0.02) ***	0.09 (0.02) ***
Reputational influence (H2)	0.07 (0.01) ***	0.04 (0.01) ***
Institutional influence	-0.19 (0.14)	-0.57 (0.12) ***
Forum co-participation (H3)	0.30 (0.05) ***	0.10 (0.04) *
Forums participated	0.01 (0.01)	0.00 (0.01)
Co-operation	1.25 (0.10) ***	1.19 (0.10) ***
Endogenous terms		
Reciprocity	1.28 (0.13) ***	0.59 (0.14) ***
GWESP *(d = 1.0)*	0.74 (0.15) ***	0.50 (0.07) ***
GWDSP *(d = 1.0)*	-0.11 (0.01) ***	-0.13 (0.01) ***
GWI *(d = 1.0)*	3.72 (1.52) *	1.31 (0.55) *
Goodness-of-fit		
AIC	3043	2616
BIC	3109	2682
Log-likelihood	-1511	-1297
AUC-PR	0.73	0.58
AUC-PR null	0.40	0.29

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

The findings indicate that policy forums potentially enable not just cognitive, but also relational policy learning. However, the median probability of an information exchange tie existing between a pair of actors that co-participate in at least one forum is substantially higher for the information exchange network (0.62) than for the trusted information exchange network (0.32). Because echo chamber effects are still in operation, it is possible that they govern the behaviour of actors *in* forums, especially in the most polarised ones, potentially diminishing the potential of forums in breaking up the echo chambers.

4. Discussion and conclusion

4.1. Contributions

To record and understand some of the controversies related to the accelerating pace and magnitude of land cover change to large-scale tree plantations, this dissertation has adopted an approach that embraces methodological holism. This was achieved by going beyond any single disciplinary tradition in social sciences while incorporating insights also from natural sciences. Such approaches are necessary to grasp the systems thinking necessary for the analyses of environmental change. Through the four articles situated under a more general framework for empirical analysis, this dissertation fills (but does not close) two gaps in the existing literature on the human impacts and governance of large-scale tree plantations. Each article also makes a more specific empirical or theoretical contribution.

Articles I and II contribute to the human impacts dimension. Article I offers an updated account of the available literature on the socio-economic impacts of large-scale tree plantations for local communities. It identifies recurring patterns of impacts, which largely corroborate the findings from previous reviews dealing with tree plantations or similar land uses, such as those by Charnley (2005) and Hunsberger et al. (2017), respectively. A key contribution of article I, however, is the mapping of the knowledge gaps in the evidence base, including the spatial and temporal biases and a number of less-researched impact categories (e.g., changes in health, income, and ecosystem services). Moreover, the review backs the notion of the many negative human impacts of large-scale tree plantations having their roots in governance, rather than management, failures.

Article II extends this contribution by providing a nuanced description of the peculiarities and the broader consequences of the major changes in land cover, land use, and related institutions from the perspective of a very specific group of livelihood practitioners: Uruguayan beekeepers. It answers the question of how the members of this community experience the multiple challenges facing them and contributes to our understanding of the capacity of rural communities that disproportionately rely on something as abstract as biodiversity and ecosystem services to adapt and transform with change. Bees also sense and rapidly react to environmental change, implying that the challenges faced by beekeepers open a window to detect, anticipate, and govern feedbacks in this social-ecological system.

Using the same data, articles III and IV are closely connected. Both contribute to the governance dimension of this dissertation. Article III identifies two competing coalitions in the turbulent context of South African tree plantation policy – indeed, the policy beliefs of the dominant business-as-usual coalition also seem to link to the observed policy outcomes. Furthermore, article III clarifies the theoretical relationships between the different types of beliefs within the three-tiered belief system of the ACF, focusing on the role that beliefs concerning specific policy instruments play in coalition formation. Article IV, in turn, contributes to our understanding of the role of policy forums for breaking up the echo chamber effects to enable policy learning. In this policy context, forums seem to *enable* both cognitive (knowledge gains) and relational (improved relations) learning. Because of echo chamber effects being in operation, however, it appears that they may

also operate in forums, especially in the most polarised ones. There are also several actors who do not participate in any of the forums. Given the findings of the articles I and II, rural communities are, unsurprisingly, neither well-represented in the policy context nor in any of the forums. More generally, article IV supports the idea that echo chamber effects govern policy actors' information exchange behaviour in complex institutional systems and are likely to reinforce the coalition lines that were identified in article III.

Beyond the individual contributions of the four articles, this dissertation proposes a general framework for the empirical analysis of the social-ecological dynamics in the context of large-scale tree plantations. It may serve as a basis for further analyses within and across diverse contexts, being potentially applicable also to other types of large-scale land-based investments.

4.2. Limitations

This dissertation has a number of limitations. I outline the main limitations identified in respect to each of the four articles as well as the overall research design of the dissertation.

Article I relied on the systematic review guidelines of the CEE (2013), which meant adapting a method from medicine and clinical experiments to complex social-ecological research that deals with epistemologically challenging concepts (e.g., social marginalisation) and arises from different disciplinary backgrounds making somewhat different methodological and philosophical assumptions. In my view, these challenges are very evident in article I, yet they remain such for most *evidence* syntheses dealing with complex phenomena (Game et al. 2018). Our team was interested in reviewing all types of impacts without prescribing their range, but which also made evaluations and categorisations of impacts utterly burdening. Because of the limitations in the available literature (e.g., the spatial and temporal concentrations of research, scant use of counterfactuals in research designs, and varying level of detail in reporting), article I is unable to deliver a comprehensive global account of *all* the socio-economic impacts of large-scale tree plantations for local communities. A review is only as accurate and extensive as are the case studies that it reviews. Article I certainly confirms the notion of the loss of customary access to land and livelihoods leading to drastic impacts, but the evidence under the other impact categories is less consistent across contexts. Although counterfactuals certainly are important for impact evaluations (Sills et al. 2017), establishing them is another methodological challenge manifest in article I. It is likely that there is also a wider range of impacts out there than what emerged from the reviewed case studies.

In addition, the categorisation of the case studies in groups A and B did not produce any major differences in terms of impacts or their characterisations. The design of the quality assessment tools can potentially alter, or even reverse, the findings from systematic reviews (Bilotta et al. 2014). This must be acknowledged also in the case of article I. However, it seems unlikely that our findings would have considerably diverged by designing the tool differently.

Reflecting some of the challenges of article I, article II is unable to show the magnitude of the many simultaneous challenges faced by beekeepers that were mainly analysed

through their subjective worldviews (although we employed triangulation). Nonetheless, the analysis seems valid in the sense that beekeepers have reportedly organised protests (i.e., a feedback) recently in the capital city of Montevideo, citing *unprecedented difficulties*, while the green party of Uruguay established in 2013 campaigns for the protection of beekeeping by law (El Observador 2019; El País 2019). The exploratory approach of article II implies that there is a need for confirmatory approaches based on working hypotheses concerning the behaviour of the beekeepers (some of which could be based on the findings of article II). The data, although collected until saturation, are based on a small number of interviews, and concern only a very specific group of livelihood practitioners in Uruguay. Article II is thus unable to say much about the broader human impacts of large-scale tree plantations in Uruguay. This in fact gave impetus for conducting the systematic review that resulted in article I.

Regarding the governance dimension, article III has limitations for reasons such as the timing of the data collection in South Africa. It took place in 2017 at the peak of many years of economic stagnation and protracted uncertainty, during which the views across coalitions could have further polarised. The questions that were asked allowed the representatives of the organisations to express concerns and provide a realistic account of the policy debates that they are most likely to engage with; however, this meant that all organisations voiced a range of concerns and all representatives did not express a clear stance on each of the policy beliefs that were used in the analysis. Policy actors, however, are known to play different roles as members of coalitions (Weible et al. 2019): others occupy more central and others more peripheral or specialised roles. Another limitation is that the research design did not specifically elicit on political collaboration, which means that the observed co-ordination network relies on voluntary information exchange with trusted partners. The psychological safety brought about by trusting somebody, however, is likely to unleash one's willing contribution to collective effort – that is, collaboration (Edmondson 2004).

Article IV focused on gaining understanding of what fosters or impedes policy learning. One of its potential limitations is its inability to distinguish between senders and receivers of information as well as between the different types of information (strategic-political or scientific-technical). These dimensions, however, have been studied elsewhere (Leifeld and Schneider 2012; Fischer et al. 2017). Another limitation is the operationalisation of the concept of policy learning. Article IV (as well as article III) relies on self-reported recognition of information exchange partners and organisational trust. However, this approach made it possible to measure the interactions and beliefs among the actors in the network and use statistical inference in their analysis. The cross-sectional data also prevented us from investigating normative policy learning – that is, whether actors changed their beliefs after exchanging information with those who they met in the policy forums. An obvious limitation concerning both articles III and IV is that they rely entirely on the South African case. More generally, the limited generalisability of insights is an inherent trade-off of adding context and complexity to the analyses of governance.

The overall research design of this dissertation would have benefitted from a theoretical framework that would have laid better foundations for accommodating all the empirical contributions under one roof. I started from simpler concepts and frameworks for the analysis of ecosystem services, which worked well for article II. However, those frameworks were unable to grasp some of the more complex phenomena in the social

system (articles I, III, and IV). This dissertation is thus an attempt to recast insights from multiple concepts and theories that emerge from somewhat different disciplinary backgrounds. It has not been a straightforward task. Ideally, all empirical contributions would also have dealt with the *same* social-ecological system (rather than *similar* systems) to link them to each other more concretely. Because of the limited resources and other practical reasons, however, this was not possible.

4.3. Ways forward

This dissertation paves the way for a number of research avenues to be investigated. The contribution of the article I can in itself be understood as a way forward – that is, a road map to filling the many remaining knowledge gaps. Ideally, research designs would employ counterfactual, longitudinal, and cross-comparative approaches. Future reviews should also go further in analysing the links between the context, institutions, mechanisms and impacts to clarify how, when, where and why large-scale tree plantations contribute to more positive or more negative impacts (McLain et al. 2017). However, it may require one to focus on a narrower array of impact categories to be able to better capture and bring forward such nuances. Moving beyond the local level to consider the socio-economic impacts of plantations and their distribution along the global commodity chains is another avenue for further investigation (Bair and Werner 2011).

Based on the exploratory findings of article II, one could test working hypotheses regarding the behaviour of beekeepers or similar actors through the modelling of the social-ecological interactions and the behaviour of actors in response to environmental change. Hypotheses could be based on the observed tendencies of beekeepers to migrate, the role of social networks for improving the capacity to adapt, or the link between the diversity and proximity of vegetation and the viability of beekeeping. Bodin and Tengö (2012) propose a theoretical framework for such attempts based on the notion of social-ecological fit, of which empirical applicability they demonstrate in the context of rural forest-dependent communities in Madagascar. These communities were able to preserve their patchy forests through various mechanisms despite external pressures on land.

Some of the impacts identified in article I (although touched upon in article II as well) were rooted in governance failures, which articles III and IV, in turn, aimed at understanding by using empirical data from the context of South African tree plantation policy. Based on article III, it appears that the conditions under which beliefs concerning specific policy instruments contribute to coalition formation require further inspection. For example, Metz et al. (2018) showed that actors might be inclined to exhibit interdependent *belief portfolios* concerning multiple policy instruments when they belong to the same coalition, which is an intriguing interpretation awaiting to be investigated in other contexts. In the South African case, media debates, for example, warrant more attention. Analysing them could help detecting additional actors, beliefs, and coalitions.

Based on the findings of article IV, organising policy forums carry potential for enabling both cognitive (knowledge gains) and relational (improved relations) policy learning. However, research has yielded somewhat inconsistent findings in terms of the usefulness of policy forums for learning (Wagner and Ylä-Anttila 2018; Fischer and Maag 2019). For those organising and analysing forums, Reed et al. (2018) propose a theory

of actor engagement based on four factors that they suggest may explain much of the variation in outcomes (for solving social-ecological problems) from different types of engagement based on agency (who initiates and leads engagement) and mode (from communication to co-production). The four factors to consider (and overcome) are contextual factors (e.g., culture of participation), process design factors (e.g., preliminary consultations), cultural-cognitive and power asymmetry factors (e.g., echo chamber effects), and spatial and temporal factors (e.g., reach and longevity of engagement).

There are also many less-researched hypotheses that call for testing across policy contexts. For example, policy forums at lower spatial levels may be more likely to attract those who are spatially closer to one another and familiar with the context, culture, and problems, which may lower the bar from collective action (Hamilton and Lubell 2018). A shared understanding of the endangerment of the common-pool resources has also been found to complement the positive effect of policy forums for collective action (Herzog and Ingold 2019). In terms of plantations, the spread of wildfires (or other relevant phenomena that spread in ecological networks) could also shape the patterns of collective action (Bodin et al. 2019; Hamilton et al. 2019); yet, this implies that producers would be willing to compromise on productivity (McWethy et al. 2018). Nonetheless, complex institutional systems and the rapid development of network methods offer numerous options for expanding the analyses of governance of social-ecological systems (Berardo and Lubell 2019; Scott and Ulibarri 2019).

Large-scale tree plantations often have a negative image. In the light of this dissertation, there are some good grounds for that image. Many of the problems are rooted in the cultural-cognitive institutions, which *can* change, but remedying the many forces that contribute to the reproduction of problems also seems utterly difficult under the current economic and legal frameworks. Smallholders are also increasingly contributing to wood production around the globe (Liu et al. 2017; Arvola et al. 2019), yet it remains unclear whether the institutions that accompany this type of expansion are any different – and if not, whether these institutions carry the risk of reproducing the problems of their large-scale counterparts or creating other problems (e.g., because of power asymmetries in commodity chains).

A number of societies in the history of humanity have demonstrated abilities to detect changes in ecosystems early enough, co-ordinate decision-making, act collectively, and transform with change (King 1995). Identifying factors that contribute to the sustainability of our contemporary society, and in ways that those making the decisions can promote them, has probably never been more urgent than it is today.

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Supplementary information

S1. Variables in the extraction sheet for article I

S2. Semi-structured interview guides for article II

S3. Semi-structured survey form for articles III and IV

S1. Variables in the extraction sheet for article I

To ensure consistency, most variables employ fixed response options, which are not provided here. The completed extraction sheet (i.e., the data) is available through Mendeley Data at:
https://doi.org/10.17632/zn68xjpmnr.1

IDENTIFICATION
Study; Case; ID; Reviewer 1; Reviewer 2

BIBLIOGRAPHY
First author; Collaborating author(s); Possible conflicts of interest in authors' affiliations or funding sources; Publication year; Title; Type; Language

DATA AND METHODS
Year(s) that the data covers; Study approach; Study design; Main method of data collection; Nature of the data; Comparator; Specify comparator, if available

EXPOSURE
Ecozone; Country; Location where plantation-community interactions occur; Main commercial purpose; Material processing; Additional incentive for planting trees in this location other than market demand for materials or services from plantation; Additional information regarding the additional incentive, if available; Characterization of the tree plantation area under study; Physical scale of planted area; Formal tenure regime; Time since the first trees were planted at the time of the study; Number of rotations at the time of the study; Certification; Work at plantation is mainly conducted by…; Work is conducted…; Primary species planted; Secondary species planted; Tertiary species planted; Integration of local livelihoods with tree planting; Main land use prior to tree plantation establishment; Current main land use around the tree plantation

POPULATION
Characterization; Average distance from plantation; Type of consultation with the local community in the early stages of operations; Local response to the type of consultation; Land acquisition approach; Additional incentives offered to the local community, if any; Noteworthy demographic or socioeconomic baselines prior to tree plantation establishment

IMPACTS
Impact category (maximum of four categories per case study); Short description of the impact; Characterization of the impact as stated by the authors; Associations between categories; Nature of the association; Gender-disaggregated impacts; Ethnicity-disaggregated impacts; Notes, if any

CRITICAL QUALITIES
Key results and conclusions are logically derived and supported by the data and methods; Confounding factors that could have influenced the validity of data and methods are considered; A clear and appropriate comparator is present

GENERAL QUALITIES
Key terms and concepts are clear, replicable and reliable; Data collection methods are clear, replicable and reliable; Sampling selection is explained; Sampling selection is justified; Data analysis methods are clear, replicable and reliable; Key conclusions and recommendations are logically derived and supported by the results Group; Notes, if any

S2. Semi-structured interview guides for article II

Separate guides were used to frame the semi-structured interviews. However, these guides were used flexibly, and the order of the questions varied along the conversation. The structures of the guides also developed during the research process as our awareness of the key issues increased.

Before starting the interviews, all participants were assured of the confidentiality, purpose and affiliates of the study, and their complete freedom of expression and freedom to drop out at any stage. None of the participants were allowed to see or study the guides in advance or during the interview. Interviews were recorded in audio (Group A) and audio-visual (Groups B, C, D) formats on the permission of the participant.

 # : Questions / themes that were inquired from the participant.
– : Occasionally used prompts to stimulate conversation or specify causes.

GUIDE FOR GROUP A
Representatives of the honey processing industry in Europe

1. Does your firm import honey from Latin America?
– The basic process of trading honey in the global market
– Mechanisms: prices, trust, former trade relations, etc.

2. What requirements do you apply for your supplies?
– Regulatory measures, voluntary (social/environmental) measures
– Honey quality issues (residues and different floral origins, including eucalyptus)
– Motivations to apply standards and requirements

3. How do you perceive the differences between honeys in the European markets?
– Potential for market differentiation

4. How could the suppliers in Latin America better match your needs and requirements?
– Awareness of environmental and socioeconomic changes and concerns
– Future prospects as regards to supplies and the honey trade in Europe and globally

GUIDE FOR GROUP B *(Originally in Spanish)*
Spokesmen of governmental and non-governmental organizations in Uruguay

1. How is honey being produced and traded in Uruguay?
– From production to exportation

2. Where Uruguayan honey is currently traded to?
– Why there?
– Mechanisms: prices, trust, former trade relations, quality, quantity, etc.

3. What is the role of your organization in the sector?
– Relative to other organizations
– Objectives, activities, motivations
– Effectiveness of activities

4. What requirements apply to the Uruguayan beekeeping sector?
– Quality, quantity, production practices

5. How have the recent years been in the sector?
– Changes, shocks and trends
– Impacts
– Wider societal changes
6. How do you perceive the future of the sector?
– Viability, opportunities, threats

GUIDE FOR GROUP C *(Originally in Spanish)*
Members of agencies trading honey in and from Uruguay

1. How is honey being produced and traded in Uruguay?
– From production to exportation

2. Where Uruguayan honey is currently traded to?
– Why there?
– Mechanisms: prices, trust, former trade relations, quality, quantity, etc.

3. What is the role of a trading agency in the sector?
– Activities
– Value-addition

4. What requirements do you apply for the Uruguayan beekeepers?
– Quality, quantity, production practices

5. How have the recent years been in the sector?
– Changes, shocks and trends
– Impacts
– Wider societal changes
– Support from private or public actors

6. How do you perceive the future of the sector?
– Viability, opportunities, threats

GUIDE FOR GROUP D *(Originally in Spanish)*
Beekeepers organized in cooperatives and individual practitioners in Uruguay

A. IDENTIFICATION

1. Who are you?
– Cooperative member / members
– Individual practitioner

B. STRUCTURE OF THE ORGANISATION

2. How is the cooperative like? *(Cooperatives)*
– Number of members, when established, where located

3. How the tasks and responsibilities are organized? *(Cooperatives)*
– General assembly, directive council, fiscal commission, additional commissions
– Any hired administration or compensations for members
– Any hired workforce [permanent or temporary], their availability
– Problems

4. Why beekeeping is practiced as a livelihood in the first place?
– Primary income, secondary income, pollination services, tradition
– Days spent on beekeeping per month / year

C. PRODUCTION

5. How much honey is produced and how is the honey like?
– Number of hives, average yield per hive, types of honey produced
– Secondary products and their contribution to annual income

6. How and why do the quantities produced vary between years?
– Weather, bee health, number of flowering plants, recent changes

7. Have any problems occurred with the quality of honey?
– H2O, HMF, fermentation, residues of GMOs, antibiotics, pesticides, physical errors

8. How the pests and diseases on bees are generally treated?
– Pesticides and medicines used

9. Where your honey is extracted?
– Rented or owned facilities, machinery
– Problems

10. How are the surroundings of the apiaries like?
– Vegetation; 3 km: agriculture, afforestation, wild areas, GMOs, organic cultivations, water
– Infrastructure; 5 km: industry, airports, highways
– Changes in biodiversity [plantations, climate change], good or bad changes
– Awareness on pesticides used and GMOs near apiaries

11. Who owns the lands and is there enough lands available for beekeeping?
– Landowners, private companies, neighbours, state

12. How and how often the harvests are organized?
– Problems

13. How the frame extraction at the apiary site is performed?
– Smoke, fire, chemicals, destruction of the bees

14. Are the bees fed with any additional sugar or honey during the year?

D. COMMERCIALISATION

15. Who is the first buyer of your honey?
– Domestic exporter, foreign importer, domestic wholesaler, grocery store, consumer
– Balance between export and domestic market

16. What have been the main problems in the commercialization?
– Risk that honey cannot be sold, lack of information on markets and requirements

17. On what the price depends on?
– Demand and supply, international prices, negotiations with the buyer, quality, quantity

18. How volatile are the demand and prices?
– Shocks, trends
– Perceived complexity and risks involved

19. What are the main costs incurred from beekeeping?
– Inputs [lands, materials, equipment, machinery, energy, drums for exportation
– Quality controls, veterinary tests
– Administration
– Perceived profitability of beekeeping

20. Have you considered direct exportation? Why?

E. SOCIAL ISSUES

21. How is the nature of a beekeeper?
– Small producers, live on farms or in cities, health, average age

22. How is the spirit in the cooperative / community at large?
– Conflicts due to sales, income distribution, responsibilities
– Training or other gatherings among members

23. Where do you receive information necessary to practice beekeeping as a livelihood?
– Cooperative, Internet, institutions, newspapers
– Availability of relevant information
– Information most needed [production, marketing, prices, financing or market requirements]

F. FINANCIAL ISSUES

24. How the financing of the cooperative is organized? *(Cooperatives)*
– Debt, loans, savings, funds, capital from members
– Availability of financing options
– Problems

25. How the income distribution is organized?
– When income is needed the most

G. DEVELOPMENT

26. What would you like to develop in your organization?

27. Have you made or considered any investments in beekeeping? What kinds?
– Certification, more hives, machinery, equipment, training, market research
– Abandonment of beekeeping as a livelihood
– Desire to develop

28. Do you receive any support from public or private programs?
– Public [MGAP, CHDA, SAU, ADEXMI] or private [buyers, banks]
– Role and importance of the existing institutions and organisations

29. How do you perceive the co-operation with the enterprises?
– Advantages and disadvantages
– Expectations

SOCIAL NETWORKING IN SOUTH AFRICAN FORESTRY

There are various views around the development of the South African plantation-based forestry sector in the next decade. The debate has concentrated around the sustainability of commercial forestry in the country under the many environmental and socio-economic pressures; including water scarcity, land claims, and economic empowerment of historically disadvantaged communities.

This questionnaire concerns the activities and interests of, and networking between the key stakeholder groups in South African forestry; including government, research, industry, labour, civil society, and traditional leadership. The interview will last between 40 to 60 minutes.

Your name and title will be kept confidential. The data gathered through this questionnaire will be handled confidentially. You have the right to withdraw from the interview at any stage or leave any of the questions unanswered. Except for storing a perfectly anonymised bulk data set to the Finnish Social Science Data Archive to promote scientific transparency [www.fsd.uta.fi/en], nothing will be passed on to third parties. The data collection will be completed by the end of 2017, and the results will be sent to all interested parties on request.

This study aims at understanding how the different stakeholders in South African forestry are connected to one another, and how information exchange, trust, and shared activities and beliefs shape the structure of the social network.

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Interview	
Interviewer	
Date	Year: Month: Day:
Time	From: To:
Province	
Location	

Organisation	
Name	
Headquartered in	Province City
Subunit	Yes No
Name of head organisation	
Headquartered in	Province City

Representative	
Name	
Title	
Telephone	
Email	
Position	Brief description of the position in the organisation
Consent	Yes No

Section A. Activities

1. For how long has your organisation been active in forestry-related activities?

2. What is the main mandate of your organisation?

3. Relative to your main mandate, please indicate how important part (i.e., level of engagement) in your organisation's work do the following activities play.

	Not important at all	Not very important	Somewhat important	Very important	Our core activity
Operations					
Growing and harvesting timber in large-scale for industrial purposes					
Growing and harvesting timber in small-scale for industrial purposes					
Sawmilling timber					
Processing pulpwood					
Manufacturing utility or mining poles					
Manufacturing charcoal or fuelwood					
Contracting labour					
Providing labour and inputs for the sector					
Promoting the competitiveness of the sector					
Investing in the sector					
Raising awareness on sector-related operations					
Environmental issues					
Biodiversity conservation					
Pest and pathogen control					
Fire prevention and management					
Climate change mitigation and adaptation					
Water management and conservation					
Raising awareness on sector-related environmental issues					
Social issues					
Providing services and amenities to the rural areas					
Developing the skills and knowledge of historically disadvantaged individuals [HDIs]					
Developing markets for and capacities of HDI-owned enterprises [contractors, out-growers]					
Diversifying the managerial and ownership profile in enterprises					
Recognising people's right to own and control land					
Resolving land claims					
Facilitating land redistribution					
Raising awareness on sector-related social issues					
Policy formation					
Direct policy formation and implementation; drafting of laws, codes or charters					
Indirect policy formation; lobbying or protesting					
Research and education					
Natural science and technological research and education [ecology, biotechnology etc.]					
Social science research and education [economy, equity, governance etc.]					
Other activities, specify					

Section B. Preferences

4. What kind of change or development is your organisation hoping for the South African forestry sector in the medium term; in the next ten years?

5. What kind of change or development is your organisation expecting to occur in the medium term, if any?

6. What do you think are the main barriers for realising your preferred vision and how to overcome them?

[co-ordination, paradigms, environmental issues, social issues, politicisation, multi-functionality, certification]

7. What do you think will be the consequences of introducing 100 000 hectares of new afforestation into the provinces of Eastern Cape (and possibly KwaZulu-Natal) in the next 10 years, if implemented?

[effectiveness, equity, efficiency]

Section C. Networking

8. Please use the table below to indicate the **nature of relations, formal or informal,** that your organisation has had with other **sector-relevant** organisations in South Africa over the last three years. Please leave the row empty, if unknown or no contact made.

	Regularity of exchange of information			Other types of exchange, if any				Overall trust to this organisation					Stands out as especially influential	You often find yourself disagreeing with
	Monthly or more often	Rarely or few times a year	Only when necessary	Resources, specify	Other, specify	Funds, coming from	Funds, headed to	Zero	Low	Mediocre	High	Complete		
Government dept. and agencies														
Dept. of Agriculture, Forestry and Fisher.														
Dept. of Environmental Affairs														
Dept. of Rural Development and Land R.														
Dept. of Science and Technology; NRF														
Dept. of Trade and Industry														
Dept. of Water and Sanitation														
Ezemvelo KZN Wildlife														
Fibre Prod. & Manuf. Skills Education Tr.														
Forest Sector Charter Council														
Industrial Development Corporation														
National Forest Advisory Council														
South African National Parks														
South African National Biodiversity Inst.														
Scientific organisations														
Council for Scientific and Ind. Res.; NRE														
Institute for Commercial Forestry Res.														
Forestry & Agricultural Biotech. Inst.														
Nelson Mandela Univ.; School of NRM														
South African Water Research Comm.														
Univ. of KwaZulu-Natal; Chem. Eng.														
Univ. of KwaZulu-Natal; Dev. Stud.														
Univ. of KwaZulu-Natal; Geography														
Univ. of Pretoria; For. Sci. Post-gra. Prog.														
Univ. of Stellenbosch; Dept. of FWS														
Univ. of the Witwatersrand; Sch. of APES														
Univ. of Venda; Dept. of Forestry														
Interest groups														
Chem. Ene. Pap. Prin. Wo. Al. Wo. Union														
Food & Allied Workers' Union														
Forestry South Africa														
Forest Industry Training Providers As.														
Paper Manufacturers As. of South Africa														
Sawmilling South Africa														
South African Utility Pole As.														
South African Wood Preservers As.														
South African For. Far. Ca. Al. Wo. Union														
South African Forestry Contractors As.														

	Regularity of exchange of information			Other types of exchange, if any				Overall trust to this organisation					Stands out as especially influential	You often find yourself disagreeing with
	Monthly or more often	Rarely or few times a year	Only when necessary	Resources, specify	Other, specify	Funds, coming from	Funds, headed to	Zero	Low	Mediocre	High	Complete		
Private sector														
Merensky														
Mondi; Zimele														
MTO														
NCT Forestry Co-operative														
PG Bison														
R&B Timber Group; Masonite														
Rance Timber; Amathole Forestry Company														
Sappi														
SAFCOL; Komatiland Forests														
Timrite														
TWK Agri														
York Timbers														
Civil society														
Association for Rural Advancement														
GeaSphere														
Forest Stewardship Council Africa														
Lima Rural Development Foundation														
Timberwatch Coalition														
Wildlife and Env. Soc. of South Africa														
World Wide Fund for Nature South Africa														
Other														
Fort Cox College; Dept. of Forestry														
KwaZulu-Natal Land Reform Benef.;SQF														
SA Forestry Magazine														
Wood SA & Timber Times														
Southern African Institute of Forestry														
Other, specify														

SECTION D. Policy formation

9. Can you comment on the nature and effectiveness of the sector-related policy formation in South Africa?

[access to information, inclusiveness of stakeholder participation, quality of participation]

10. Do you feel that the voice of your organisation has been seriously considered?