UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG

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The Causal Power of the Possible

Navigating Complexity and Uncertainty in Adapting Forests to Climate Change in the Swiss Alps

Faculty of Science and Medicine

DOI : https://doi.org/10.51363/unifr.sth.2026.072

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THESIS
presented to the Faculty of Science and Medicine of the University of Fribourg (Switzerland)
in consideration for the award of the academic grade of
Doctor of Philosophy in Geography
by
Jan Zumoberhaus
from
Horw (LU), Switzerland

Thesis No: 8136
Uniprint UniFr
2026

Accepted by the Faculty of Science and Medicine of the University of Fribourg (Switzerland) upon the recommendation of:

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Fribourg, 18.05.2026

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« Pour ce qui est de l'avenir,
il ne s'agit pas de le prévoir,
mais de le rendre possible. »

Antoine de Saint-Exupéry, *Citadelle*, 1948[1]

[1] "As for the future, it is not a matter of predicting it, but of making it possible." Entry quote to the IPCC Special Report on the impacts of global warming of 1.5° (Intergovernmental Panel on Climate Change, 2019:xi).

Content

Abstract

Forests provide essential services such as timber production, recreation, and protection against natural hazards. Yet they adapt only slowly to rapidly changing climatic conditions, and the concrete effects of climate change on forest ecosystems remain highly uncertain. This thesis examines forest adaptation to climate change (FACC) in Valais, Swiss Alps, as a case for understanding how change in socio-ecological systems is interpreted, managed, and negotiated in practice.

In response to climate change, forest science increasingly draws on the concept of complex adaptive systems. This perspective emphasises resilience, diversity, and learning instead of command-and-control management. In contrast, much social science research on FACC engages only superficially with complexity and uncertainty, often reducing them to questions of perception. This thesis moves beyond such approaches by treating uncertainty as a fundamental condition of action. Practice depends both on available knowledge and on the openness of the future.

The study adopts critical realism as its theoretical framework. This perspective holds that reality exists independently of humans' knowledge, that knowledge is always fallible, and that practice emerges from actors who are embedded in—and actively shape—the world around them. Building on this foundation, the thesis introduces the concept of *the possible* as a key analytical lens. Rather than viewing uncertainty as a deficit, this concept highlights the range of alternative futures that actors confront when making decisions under conditions of change.

Empirically, the study is based on an abductive discourse analysis of interviews and documents from Valais. Three main findings emerge. First, foresters operate in a complex and uncertain environment, yet this uncertainty encourages ongoing reflexive engagement with forest ecosystems and one's own knowledge. Second, forestry practice is characterised by trial-and-error processes whose results often become visible only in the far future, but practice nevertheless continues despite this incomplete knowledge. Third, this form of practice encounters contradictions with socio-political expectations that prioritise stability, rationalisation, and measurable outcomes, thereby limiting engagement with alternative futures.

The thesis argues that greater attention should be paid to the practical necessity of acting under uncertainty. This involves recognising both the risks and possibilities inherent in forest management, reconsidering forestry's goals and norms, and moving beyond an exclusive focus on measurable results. More broadly, the study contributes to debates on society–nature relations by emphasising the limited, fallible, and provisional place humans occupy in the natural world, while also acknowledging that they are part of—and dependent upon—the very world they seek to understand and manage.

Zusammenfassung

Wälder erbringen wichtige Leistungen wie Holzproduktion, Erholung und Schutz vor Naturgefahren. Allerdings passen sie sich nur langsam an die sich rasch verändernden klimatischen Bedingungen an, und die konkreten Auswirkungen des Klimawandels auf Waldökosysteme sind nach wie vor mit grosser Unsicherheit behaftet. Diese Dissertation untersucht die Waldanpassung an den Klimawandel im Wallis in den Schweizer Alpen als Fallbeispiel, um zu verstehen, wie Veränderungen in sozioökologischen Systemen in der Praxis interpretiert, bewältigt und ausgehandelt werden.

Als Reaktion auf den Klimawandel greift die Forstwissenschaft zunehmend auf das Konzept komplexer adaptiver Systeme zurück. Diese Perspektive betont Resilienz, Diversität und Lernen anstelle eines Command-and-Control-Managements. Im Gegensatz dazu setzt sich ein Grossteil der sozialwissenschaftlichen Forschung zur Waldanpassung an den Klimawandel nur oberflächlich mit Komplexität und Unsicherheit auseinander und reduziert diese oft auf Fragen der Wahrnehmung. Diese Arbeit geht über solche Ansätze hinaus, indem sie Unsicherheit als grundlegende Bedingung des Handelns begreift. Praxis hängt sowohl vom verfügbaren Wissen als auch von der Offenheit der Zukunft ab.

Die Studie stützt sich auf den kritischen Realismus als theoretischen Rahmen. Diese Perspektive geht davon aus, dass die Realität unabhängig vom menschlichen Wissen existiert, dass Wissen stets fehlbar ist und dass Praxis von Akteur*innen entsteht, die in die sie umgebende Welt eingebettet sind und diese aktiv gestalten. Auf dieser Grundlage führt die Arbeit das Konzept des Möglichen als zentrale analytische Perspektive ein. Anstatt Unsicherheit als Defizit zu betrachten, hebt dieses Konzept die Vielfalt alternativer Zukunftsszenarien hervor, mit denen Akteur*innen konfrontiert sind, wenn sie unter sich verändernden Bedingungen Entscheidungen treffen.

Empirisch stützt sich die Studie auf eine abduktive Diskursanalyse von Interviews und Dokumenten aus dem Wallis. Daraus ergeben sich drei wesentliche Erkenntnisse. Erstens agieren Förster in einem komplexen und unsicheren Umfeld, doch diese Unsicherheit fördert eine kontinuierliche reflexive Auseinandersetzung mit Waldökosystemen und dem eigenen Wissen. Zweitens ist die forstwirtschaftliche Praxis durch Trial-and-Error-Prozesse gekennzeichnet, deren Ergebnisse oft erst in ferner Zukunft sichtbar werden, aber trotz dieses unvollständigen Wissens wird die Praxis dennoch fortgesetzt. Drittens stösst diese Form der Praxis auf Widersprüche zu gesellschaftspolitischen Erwartungen, die Stabilität, Rationalisierung und messbare Ergebnisse priorisieren und dadurch die Auseinandersetzung mit alternativen Zukunftsszenarien einschränken.

Die Arbeit vertritt die Auffassung, dass der praktischen Notwendigkeit, unter Unsicherheit zu handeln, mehr Aufmerksamkeit geschenkt werden sollte. Dies beinhaltet, sowohl die Risiken als auch die Möglichkeiten anzuerkennen, die der Waldbewirtschaftung innewohnen, die Ziele und Normen der Forstwirtschaft zu überdenken und über eine ausschliessliche Fokussierung auf

messbare Ergebnisse hinauszugehen. Im weiteren Sinne leistet die Studie einen Beitrag zur Debatte über die Beziehungen zwischen Gesellschaft und Natur, indem sie die begrenzte, fehlbare und vorläufige Stellung des Menschen in der natürlichen Welt hervorhebt und gleichzeitig anerkennt, dass der Mensch Teil jener Welt ist, die er zu verstehen und zu gestalten versucht, und von ihr abhängig ist.

Acknowledgements

This dissertation would not have been possible without the support, encouragement, and generosity of many people. I am deeply grateful to all those who accompanied me throughout this journey.

First, I would like to thank the individuals from my field who generously agreed to participate in interviews for this research. Their willingness to share their experiences and perspectives provided an essential foundation for this work. I am also grateful to the many people I met at conferences and workshops whose questions, comments, and discussions challenged and enriched my thinking. My sincere thanks also go to the members of my dissertation jury—Leigh Price, Norman Backhaus, and Roderich von Detten—for the time and care they invested in reading and evaluating this thesis, and for the stimulating discussion during the private defence. I would also like to acknowledge Martin Hölzle for jumping in as jury president.

My deepest gratitude goes to my supervisor, Olivier. Without his encouragement, I would never have embarked on this dissertation, and without his continued support, I would not have completed it. Together with my accompanying jury members, Christine and Norman, he provided invaluable guidance, thoughtful feedback, and encouragement throughout the entire process. Beyond his academic support, Olivier offered stability and reassurance during periods of uncertainty when I was unsure whether, and how, to continue.

Special thanks go to my fellow PhD students at the Department of Geosciences: Alex, Anouk, Benji, Dilara, Dominik, Enrico, Esther, Hanna, Giona, Gwen, Joshua, Jueling, Julie, Lea, Lena, Katarina, Marcus, Martin, Nico, Nicole, Paula, Romain, Sarah, Simon, Surya, Tamara, Toma, Tomasz, and Tristan. The years we shared were filled with hikes, dinners, retreats, and countless hours of babyfoot. These moments brought not only friendship and joy, but also inspiration, support, and a sense of belonging. I will always remember them as my PhD family.

Among them, I would particularly like to thank Jueling. Over several years, we shared not only an office but also many moments beyond it—during hikes in the mountains, walks through the city, and long discussions on my balcony. Although we often disagreed on many aspects of science, our conversations broadened my perspective and helped me see the world through different lenses. I am grateful for that exchange.

I am equally thankful to many other colleagues in the department. In particular, I would like to acknowledge Alex, Nicole, and Sylvie for their invaluable support with administrative and technical matters. I also benefited greatly from the exchanges I had with numerous postdoctoral researchers and professors whose diverse disciplinary perspectives enriched my understanding of many topics. One of the department's greatest strengths lies in this intellectual diversity, and I

hope it will continue to foster an environment characterised by mutual respect, curiosity, and exchange.

I owe particular thanks to Mathilde for the teaching we shared, the reflections that emerged from it, the opportunity to practise my French, and the many moments beyond work through which she supported me in countless ways.

I am also grateful to the many students I have taught over the past years. While I hope they took something valuable away from my classes, I know with certainty that I learned a great deal from them in return.

Beyond the Department of Geosciences, I would like to thank several people whose friendship and companionship have accompanied me throughout these years. In particular, I am grateful to Anna, Jana, Eliane, Luca, and Selim for maintaining our friendship and exchange long after our years of study together. My thanks also go to Andreas for being an exceptional discussion partner on the topic of Critical Realism. I am equally grateful to the many others with whom I shared memorable moments, conversations, and experiences along the way.

Finally, my heartfelt gratitude goes to my family, especially my parents. Their emotional support provided a foundation on which I could always rely. Through them, I always knew that I had people and places to turn to whenever I needed distance from my work, perspective, or simply a moment of calm. The value of having such support is impossible to measure, and I am profoundly grateful for it.

Abbreviations

AI	Artificial intelligence
CHF	Swiss franc
CR	Critical realism
DCR	Dialectical critical realism
ETHZ	Swiss Federal Institute of Technology Zurich *(Eidgenössische Technische Hochschule Zürich)*
FACC	Forest adaptation to climate change
FOEN	Federal Office of Environment *(Bundesamt für Umwelt BAFU)*
IPCC	Intergovernmental Panel on Climate Change
NaiS	Sustainability and performance monitoring in protective forests *(Nachhaltigkeit und Erfolgskontrolle im Schutzwald)*
RCP	Representative concentration pathway
SDM	Species distribution model
SRF	Swiss Broadcasting Corporation *(Schweizer Radio und Fernsehen)*
VS	Valais
WaMos	Socio-cultural forest monitoring *(Waldmonitoring soziokulturell)*
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research *(Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft)*

Chapter 1: Introduction

The Lötschberg South Ramp (Lötschberg-Südrampe)[2] in Valais, in the Swiss Alps, forms a south-facing slope of the Rhône Valley. The landscape is marked by rugged rocky outcrops, steppe-like grasslands, juniper shrubs, and sparse forests. Small villages, isolated houses, roads, a railway line, and agricultural plots are scattered across the terrain. During summer, these agricultural areas are irrigated almost daily, as the climate can be extremely dry and, at times, sweltering.

Irrigation has a long history in this region. As early as the Middle Ages, channels—known as *Suonen*—were built to divert water from mountain streams to arable land. These channels, still in use today and often combined with modern sprinkler systems, made permanent settlement on this southern slope possible. Without irrigation, agriculture would fail, and much of the landscape would quickly dry out.

What makes this place unusual, however, is not irrigation itself, but the fact that forests are irrigated too. The lower forests on the southern slope of the Lötschberg are criss-crossed by traditional *Suonen*, metal pipes, and sprinkler systems. Without irrigation—activated as needed during dry summer periods—trees would not survive here. Large parts of the landscape would instead resemble the barren steppe that already characterises some areas today.

These irrigated forests owe their existence to a railway line built here just over a century ago. At the time, it was a key north–south transport route through the Alps. Forests were planted during construction to protect the railway from landslides, rockfalls, and avalanches. Although the opening of the Lötschberg Base Tunnel has reduced the line's strategic importance, it is still used primarily for freight transport, and the protective function of the forest remains essential.

The forests that grow here have a species composition found nowhere else in Switzerland or the Alps. Only a limited number of tree species can cope with the harsh conditions of heat and drought—conditions that are further shaped by continuous human intervention through irrigation. Over decades, forests and other forms of vegetation have adapted to these unique circumstances. In this sense, the Lötschberg South Ramp has already undergone significant transformation over the past centuries.

Looking ahead, equally profound changes can be expected in the coming decades. The most important driver is anthropogenic climate change. Rising temperatures are likely to result in longer and more frequent droughts. In places that are already hot and dry today—such as the south-

[2] A map showing all place names referenced in this work is provided in Section 5.1.2 (Figure 3, p. 81). Unless otherwise indicated, all place names, institutional titles, document names, and quotations originally published in German or French have been translated into English by the author. Where nuances or potential discrepancies in translation are relevant, these are explicitly noted.

facing slopes of the Rhône Valley—the question of how forests and other ecosystems can adapt is becoming increasingly urgent.

While the forests of the Lötschberg South Ramp are a particularly striking example, the challenge of forest adaptation to climate change extends far beyond this specific location. Across the world, forests are exposed to rapidly changing climatic conditions. In mountain regions such as the Alps, forests often serve not only as sources of timber, but also fulfil crucial protective functions—for settlements, transport infrastructure, and human safety. Although these forests are usually not irrigated, they have been actively managed for centuries. Here too, the question arises of how they will respond to future climatic conditions.

Beyond the biophysical processes themselves, it is therefore crucial to consider how ecological change is understood and dealt with in practice—and how these understandings, in turn, shape human interventions. In complex and open systems such as forests under climate change, past experience can no longer serve as a reliable guide for future decisions. Climatic conditions have already changed and will continue to change rapidly.

This fundamental challenge—how to engage with ecological change under conditions of complexity and uncertainty—guides this dissertation. Rather than seeking to address this challenge directly or to offer immediate solutions, the study examines how people themselves attempt to do so. It investigates how foresters and other actors, as well as society more broadly, understand and respond to these changes. In this sense, the analysis focuses on the conditions of knowledge and practice and on the social relationship to the natural world. Forest management in Valais serves as the empirical case through which these issues are explored.

The remainder of this chapter provides a broader orientation to these questions. Section 1.1 situates the study within the context of contemporary transformations of the biophysical world. Section 1.2 introduces theoretical considerations on change, complexity, and uncertainty. Finally, Section 1.3 outlines the overall approach, methodological design, and structure of the thesis.

1.1 Socioecological change in context

The local situation on the southern flank of Valais described above reflects processes of change that are also evident at the more abstract scale of contemporary global environmental change. Across regions and biomes, species are disappearing while others expand into new areas. Many organisms are altering their physiology, morphology, and phenology; plants, for instance, are growing more slowly or beginning to flower earlier in the year. These dynamics extend down to the genetic level, as shifting ranges increasingly lead to hybridisation between species. Taken together, such developments are reshaping entire ecosystems and the ecological relationships that constitute them (for an overview, see Scheffers et al., 2016).

These biological responses are largely reactions to shifts in the abiotic environment—most notably climate change—and are compounded by additional anthropogenic pressures such as land-use change, pollution, and the introduction of non-native species. Conversely, ecological change feeds back into human societies, affecting for example food security, timber availability, and the spread of disease (Pecl et al., 2017). As a result, new approaches are required at both management (Truitt et al., 2015) and governance (Clement and Standish, 2018) levels to address emerging ecological dynamics. In the current era of environmental change, a dominant strategy consists in supporting ecosystems' capacity to adapt to shifting climatic conditions. This involves not only deciding which actions are appropriate and how they can be implemented practically and politically (Hagerman et al., 2010; Stein et al., 2013; Prober et al., 2019), but also determining when intervention is necessary or justified (Fischer and Riechers, 2019).

At the same time, environmental change itself is not a novel phenomenon. Since Darwin, nature has no longer been understood as God-given or inherently stable, but as dynamic and historically contingent (Worster, 1994a:4–5). Alongside abiotic processes such as continental drift, evolutionary dynamics unfolding over millions of years have generated the ecological complexity observed today. Nature's ongoing processes of transformation are thus the source of the variability and diversity encountered in ecosystems around the world.

What distinguishes the present period, however, is the scale, speed, and causes of this change. Increasingly, it is human activity—albeit unevenly distributed across societies and regions—that is driving ecological transformation, rather than endogenous natural processes alone. This unprecedented influence is producing rates of change rarely observed in Earth's history. Concentrations of CO_2 and other greenhouse gases now exceed levels recorded over several hundred thousand years, and global surface temperatures have risen more rapidly over the past five decades than at any point in the previous two millennia (IPCC AR6 Working Group I, 2023). There is little indication that this trajectory will reverse in the near future, as global climate policy continues to struggle to achieve rapid and sufficient emission reductions.

Climate change is nevertheless often imagined as a future event—something yet to arrive. Recent developments, however, make it clear that we are already living within it. In 2024, the global 1.5 °C threshold was exceeded on a global level (World Meteorological Organization, 2025)[3], and a growing range of extreme weather events—including droughts, storms, and heavy rainfall—can now be robustly linked to climate change (Carbon Brief, 2024b). At the same time, global CO_2 emissions continue to rise (Carbon Brief, 2024a). This shift in perspective has important implications: the central question is no longer only how to prevent ecological change, but increasingly how to live with it and respond to it.

[3] In this regard, it is important to note that Switzerland—the location of the case study examined in this thesis—has already experienced a warming of approximately 2.9 °C compared to pre-industrial levels (MeteoSwiss and ETH Zurich, 2025).

Forestry is a domain in which this condition of *being within change* becomes particularly visible. Forest management operates on extended temporal scales: the long life cycles of trees require foresters to account simultaneously for past conditions and future developments in present-day decisions. At the same time, forests provide a wide range of social and ecological functions, including timber production, carbon sequestration, protection against natural hazards, and recreational value.

Accordingly, a growing body of forestry research addresses climate-induced change directly. Numerous studies examine strategies for adapting forests to climate change (for an overview, see Keenan, 2015). The uncertainty associated with these transformations is frequently highlighted (Lindner et al., 2014), alongside questions of decision-making (Yousefpour et al., 2012) and governance (Bouriaud et al., 2015) under uncertain conditions. These debates have introduced—or revitalised—concepts such as resilience, socio-ecological systems, and complex adaptive systems to capture current dynamics (e.g. Puettmann et al., 2009; Messier et al., 2015)[4]. A more detailed discussion of these approaches within forestry science follows in Chapter 2.

Despite this growing literature, however, relatively little attention has been paid to what sustained change in complex socio-ecological systems—long assumed to be comparatively stable—entails for conceptions of knowledge, practice, and the social relations in which these systems are embedded. Even less is said about how such conceptions themselves feed back into the systems undergoing change. In the following section, I therefore provide a brief overview of contrasting scientific-historical approaches to complexity and change in socio-ecological systems such as forests. These approaches help situate the empirical case of Valais—including the Lötschberg South Ramp—and the practice of forestry under conditions of climate change.

1.2 Socioecological change and the challenge of complexity

The human influence on the biophysical environment outlined in the previous section, together with the environmental changes currently underway, highlights the extent to which this environment is complex, dynamic, and mutable. Precisely this complexity and changeability have long divided paradigms within the natural sciences. Since the Enlightenment, scientific thought has oscillated between attempts to reduce biophysical reality to timeless causal laws and efforts to

[4] Beyond the academic literature, I observed that the concept of change is omnipresent in the public communication of forestry science. At the German *Forstwissenschaftliche Tagung* in autumn 2025—the largest forestry science conference in the German-speaking world—two of the four thematic sessions and the keynote address explicitly focused on “change”. The remaining sessions and the overall conference motto (“Wald neu denken”, Rethinking the Forest) invoked related notions such as “future”, “new”, and “innovation” (see Universität Freiburg, 2025). This emphasis suggests that forestry science increasingly presents itself as a discipline concerned with transformation. However, beyond these headlines and buzzwords, explicit conceptual engagement with what “change” actually entails appeared to be limited.

account for historicity, contingency, and transformation. While Isaac Newton sought to explain nature through universal and ahistorical principles, nineteenth-century natural scientists such as Charles Darwin and Charles Lyell demonstrated that nature is fundamentally shaped by history—and thus by contingency and change (Ulanowicz, 2009).

Early twentieth-century ecology likewise reflected this tension. Holistic frameworks such as succession theory and the ecosystem concept aimed to impose order and coherence on nature, while alternative approaches emphasised individualism, contingency, and instability (Worster, 1994b; Reiners and Lockwood, 2010). In physics, similar developments unfolded as relativity theory and quantum mechanics challenged mechanistic causality by demonstrating that seemingly fixed dimensions such as time and space are relative, and that indeterminacy prevails at the subatomic level (Rovelli, 2017).

Against this background, humans increasingly come into view as central producers of knowledge about the natural world. The ideal of fully objective, observer-independent knowledge becomes less plausible, even as human societies intervene ever more deeply in biophysical processes. The consequences of these interventions are particularly evident in the context of climate change. Science and society can therefore no longer be treated as separate domains; rather, they co-produce one another (Jasanoff, 2004). This raises the question how humans and societies can be analytically integrated into complex systems thinking in ways that acknowledge both their biophysical embeddedness and their distinctive social, normative, and reflexive capacities.

Although its intellectual roots can be traced back to Aristotle and ancient Greek philosophy, complexity has emerged as a defining challenge of the present. Yet there is no single or universally accepted definition of complexity or complexity thinking (O'Sullivan, 2004; Manson, 2009). It is precisely the global climate and environmental crisis—with its character as a "wicked problem" marked by unclear problem definitions, interdependent causal factors, and irreversible consequences (Hulme, 2009)—that brings complexity to the fore. In the natural sciences, complexity is often addressed through mathematical or computational models designed to capture and reduce it. In contrast, social scientists emphasise that governance can confront wicked problems only by recognising socio-ecological structures and the capacity of agency to transform them within a bounded space of possibilities:

> It is through thinking in complexity terms *and* through the recognition of the nature of socio-ecological structures and the potential for agency to transform them within the range of their possibility space that governance can confront wicked problems and overcome them (Byrne and Callaghan, 2023:1, their emphasis).

Within governance and policy research, considerable attention has therefore been devoted to strategies for dealing with uncertainty. A recurring insight is that uncertainty cannot be eliminated through the accumulation of scientific knowledge alone, nor can it always be quantified—for instance, through probabilistic models. Instead, institutional, organisational, and individual

strategies are sought to enable decision-making under conditions of deep uncertainty, where future trajectories of complex systems cannot be reliably predicted (see, e.g., Yousefpour et al., 2017; Stanton and Roelich, 2021).

Beyond its analytical relevance, complexity also fascinates many people on a more personal level—myself included. As Price (2023:12) observes with regard to Earth system models:

> There is something fantastic, incredible, and strange about the things that populate systems theory and complexity, such as fractals, the butterfly effect, strange attractors and the strong role given to chance. However, these things only seem weird or strange because current versions of systems theory do not allow for the possibility that transfactual, deep structures and mechanisms exist; to use an analogy, if one can see what the conjurer is doing behind the scenes, the event taking place becomes less magical in that it no longer defies common sense (yet it can still be breath-takingly, awe-inspiringly impressive).

In this thesis, however, I do not seek to identify such a "conjurer" or to offer a comprehensive explanation of complexity itself. Instead, I investigate empirically how complexity and environmental change are understood, negotiated, and acted upon in a concrete case. I thereby focus on the metaphysical—here primarily epistemological and ontological—assumptions that underlie contemporary complexity thinking (O'Sullivan, 2004; Byrne and Callaghan, 2023:14), as well as the commitments these assumptions entail for knowers and practitioners. In other words, this thesis explores what engagements with complexity and uncertainty reveal about the relationship between reality, knowledge, and practice.

Forest adaptation to climate change provides a paradigmatic case in this regard. Long-standing certainties are being unsettled, while new and often unexpected dynamics emerge. Although forestry science seeks to grasp these changes through models and specialised empirical research, it has become increasingly clear that natural science alone cannot fully capture the dynamics of such complex socio-ecological systems. Temporality is crucial here: climatic and environmental changes are occurring at unprecedented speed, while management decisions must be taken in the present for an uncertain—and often unprecedented—future. From a complexity perspective, forestry thus confronts a fundamentally open future:

> In a continuously changing environment, managers need to adapt to new information and can neither rely on established theoretical knowledge nor on experiential knowledge that was accumulated in an ecosystem that has undergone (under the conditions of climate change: fundamental) changes since then (Reinhold et al., 2025:3).

Accordingly, dealing with complexity, uncertainty, and openness has become a central challenge in forest management (Puettmann et al., 2009; Detten, 2011; Lindner et al., 2014; Messier et al., 2016; Reinhold et al., 2025) and in socio-ecological systems more broadly (Levin et al., 2012; Schlüter et al., 2019). While numerous approaches aim to develop forms of decision-making and governance capable of addressing these challenges (see e.g. Walker et al., 2003; Yousefpour et al., 2012; Yousefpour and Hanewinkel, 2016; Yousefpour et al., 2017; Stanton and Roelich, 2021)

two broad orientations can be identified with regard to the relationship between reality and knowledge in complexity thinking.

On the one hand, complexity is understood as a property of socioecological systems themselves. From this perspective, systems develop in non-linear and often surprising ways (Holling, 1996), characterised by spatial and temporal heterogeneity as well as feedback loops (Levin et al., 2012). Uncertainty and openness are thus located in reality itself and described as "inherent" (Holling, 1996:734), "deterministic" (O'Sullivan, 2004:283), or "ontic" (Nielsen and Ulanowicz, 2011). Scientific knowledge, from this perspective, should—if possible—represent this complex reality by reducing it to analysable components, for example through models or probabilistic estimations of system behaviour (O'Sullivan, 2004; Manson, 2009).

On the other hand, alternative approaches locate complexity and uncertainty primarily at the level of knowledge and representation. Here, such concepts are understood not as properties of biophysical reality but as metaphors (Proctor and Larson, 2005) or discursive tools (Keller, 2005; Bocking, 2015) that reflect the subjectivity or historical situatedness of knowers. From this perspective, complexity emerges from the multiplicity of local and situated forms of knowledge (Raymond et al., 2010) and is shaped by social and cultural conditions (Boholm, 2003; Brown, 2004; Derbyshire, 2020) and relations of power (Mansfield and Haas, 2006). They become objects of social scientific analysis in their own right, explained through individual, cultural, or structural factors (Proctor, 2008; Uekötter and Lübken, 2014).

Both orientations—loosely corresponding to realist and constructivist approaches to knowledge—risk falling into forms of reductionism or relativism (Cilliers, 2005; Urry, 2005; Simandan, 2010). Treating complexity solely as an inherent feature of biophysical reality can render systematic understanding or intervention futile. Conversely, reducing complexity and uncertainty to social constructions risks severing them from biophysical reality altogether. In both cases, reality and knowledge are conflated—either by assuming direct correspondence between knowledge and reality, or by reducing reality to knowledge alone.

The central problem addressed in this thesis is therefore how ecological change in complex socioecological systems can be understood and acted upon without reducing uncertainty either to an intrinsic property of nature or to a mere artefact of knowledge and discourse. To this end, I adopt a position that maintains an analytical distinction between reality and knowledge while allowing for empirical investigation of their interplay. I examine how dualisms such as structure and contingency, reality and knowledge, or nature and humans are sublated in their dialectical relationality—that is, how they are suspended and reconfigured in practical action, with knowledge itself understood as a form of action. From this perspective, complexity—and the associated openness of the future—emerges neither solely from the world nor solely from representation, but from the relationship between humans and the world as enacted in knowing and acting. This shifts the analysis away from an external, diachronic account of ecological change toward one rooted in the

immediacy of the present within a world undergoing transformation. The following section outlines the approach and structure of this inquiry.

1.3 Approach and structure of the thesis

With its focus on ecological change and complexity examined through the case of forest adaptation to climate change, this thesis is situated within the field of science and knowledge studies. This field has, on the one hand, a strong philosophical strand that employs logical and theoretical reasoning to analyse the abstract—and often seemingly universal—relationship between knowledge and reality (for a general overview, see Yearley, 2005; Chalmers, 2013; for a philosophy of ecology, see Reiners and Lockwood, 2010). On the other hand, recent decades have seen a marked expansion of empirical research that investigates the production of scientific knowledge through ethnographic and other qualitative approaches, with Latour and Woolgar's (1986) laboratory study constituting a seminal contribution. As a result, the social embeddedness of knowledge and science has become a central concern in the field.

At the same time, this work is located within the broad and heterogeneous field of environmental geography. Environmental geography is often understood as occupying an intermediate position between natural science-oriented physical geography and social science-oriented human geography. Its core concern is the relationship between nature and society (Castree et al., 2009), a relationship in which complexity and uncertainty play a key role from both natural and social scientific perspectives (Brown, 2004; O'Sullivan, 2004; Brown and Damery, 2009; Manson, 2009; Senanayake and King, 2021). Yet environmental geography, too, remains shaped by the epistemological divide between the natural and the social sciences. As a consequence, research on human–environment relations has frequently followed either a positivist orientation aimed at accurately representing an external reality, or a poststructuralist or constructivist approach that focuses on how individuals or societies construct their relationship with nature—often at the expense of engaging with the structured materiality of the biophysical world itself.

In this thesis, I do not position myself at either pole of these spectra—neither between philosophical–theoretical and purely empirical research, nor between positivist realism and constructivism—but instead seek to connect these dimensions. Critical realism provides a framework that enables such integration. As a metatheoretical position, it rests on ontological realism, that is, the assumption that a world exists independently of our knowledge of it. At the same time, it understands knowledge as a human—and therefore social—product that is necessarily contextually and conceptually dependent. This epistemological relativism does not imply that all knowledge claims are equally valid or merely subjective; rather, it acknowledges that knowledge cannot be conceived as a mirror-like correspondence to reality. Knowledge always presupposes both an

object to which it refers and the conceptual, empirical, and practical processes through which this reference is established (Bhaskar, 1978, 1998, 2008).

This perspective avoids the pitfalls of radical constructivism, which denies the existence of a mind-independent world, as well as those of naïve realism, which assumes a direct correspondence between knowledge and reality (Sayer, 2000; Danermark et al., 2002; Elder-Vass, 2012; Porpora, 2015). In any act of knowing nature, both the biophysical world and the social processes of knowledge production are already implicated. Critical realism also foregrounds materiality—a theme that has re-emerged prominently in the social sciences over recent decades—while distinguishing itself from new materialist approaches by understanding materiality not as structureless or wholly contingent, but as shaped by causal powers without lapsing into determinism (Porpora, 2017; Rutzou, 2017; Rutzou and Elder-Vass, 2019; Bråten, 2022; Porpora, 2024).

Adopting this framework allows forest adaptation to climate change to be examined empirically through a case study without resorting to a strictly idiographic approach that would treat the case as unique and incommensurable. Instead, the aim is to provide explanatory accounts of why the observed phenomena take the forms they do, while recognising that such explanations are interpretative and historically situated rather than universally valid.[5] This focus also enables a reflexive approach that interrogates both prevailing interpretations within the field of forest adaptation to climate change and my own position as a researcher—two dimensions that have so far received limited explicit attention in this field.

Against this backdrop, the thesis unfolds in several analytical steps. Chapter 2 reviews existing literature on forests and climate change from both natural and social scientific perspectives, with particular attention to the concept of uncertainty and its associated challenges. Chapter 3 then introduces critical realism as a metatheoretical framework capable of addressing these challenges on ontological, epistemological, and normative–practical levels. Building on dialectical critical realism, Chapter 4 develops a conceptual framework that rethinks uncertainty through the notion of the possible. Chapter 5 introduces the empirical case of forest adaptation to climate change in Valais and outlines the methodological approach. The empirical analysis proceeds from three perspectives: the formation of knowledge and the emergence of what I term “known uncertainty” (Chapter 6); the practical responses of foresters, conceptualised as “reflexive muddling through” (Chapter 7); and the social conditions that shape and constrain these practices, which I analyse under the heading of “actualism” (Chapter 8). Chapter 9 concludes the thesis by summarising the findings and discussing their implications for forestry and forest science, human–nature relations, and the philosophical foundations of Western modernity.

[5] It should be emphasised at the outset that the primary body of literature engaged in this thesis stems from Western—and particularly European—contexts. This reflects the empirical focus on a case study in Switzerland. This does not imply an uncritical acceptance of this context; on the contrary, Chapter 8 in particular adopts a critical stance toward dominant assumptions and practices in forest adaptation.

Chapter 2: Forest adaptation to climate change: An overview of the literature

This chapter introduces forest adaptation to climate change (hereafter FACC) as a key case of anthropogenically driven environmental change. It begins with a historical review of forestry in order to identify the paradigms that have shaped its approach to managing nature (Section 2.1). It then demonstrates how, in the context of contemporary climate change and environmental degradation, a new paradigm informed by complex adaptive systems thinking is emerging (Section 2.2). The discussion of how this paradigm is addressed in empirical social science research (Section 2.3) reveals several inconsistencies that culminate in a paradox surrounding the notion of uncertainty (Section 2.4). Building on this analysis, Section 2.5 identifies three key axes—(1) the interwovenness of society and nature, (2) the notion of change, and (3) temporality—along which the field of FACC can be rethought, and explains why traditional approaches, particularly positivism and constructivism/poststructuralism, fail to provide coherent and satisfactory perspectives on FACC.

2.1 Forestry: A history of paradigms

Societies have maintained a long and complex relationship with forests. Since prehistoric times, humans have relied on forest resources such as wood for heating, and game and berries for food. At the same time, forests have also been places of uncertainty and mystery: in 9 AD, the Romans suffered one of their most devastating defeats against Germanic tribes due, in part, to their unfamiliarity with the dark depths of the Teutoburg Forest. During the Middle Ages, forests were associated with lepers, highwaymen, and witches. In modern times, they were romanticised in painting (e.g. Caspar David Friedrich, Ludwig Richter) and in literature (e.g. Joseph von Eichendorff, Henry David Thoreau), where they were often imbued with mystical or transcendent qualities (Küster, 2003). The narrative of the dark, unknown forest persists in fairy tales and fantasy literature to this day—consider *Hansel and Gretel*, *The Lord of the Rings*, or *Harry Potter*.

Alongside these cultural interpretations, the exploitation of forest resources intensified steadily from the Enlightenment onwards—sometimes to the point of depletion. While some authors (e.g. Gleitsmann, 1989) have explained such "resource crises" through a Malthusian lens, attributing them primarily to population growth, a broader political-economic perspective reveals additional drivers. Colonial expansion and early modern warfare increased demand for wood for energy production, shipbuilding, and military equipment, leading to widespread and systematic deforestation by increasingly expansionist European powers.

This overexploitation provoked calls for more systematic and rational approaches to forest resource use. The quantification and rationalisation characteristic of Enlightenment science were

thus applied to describe—and regulate—the use of forests (Lowood, 1990). It was in this context that the Saxon chief mining administrator Hans Carl von Carlowitz, in his *Sylvicultura Oeconomica* (1713), advocated forest management based on the long-term continuity of wood supply and famously coined the term sustainability:

> Therefore, the greatest art, science, diligence and organisation of this country shall be devoted to the conservation and cultivation of wood in such a way that it can be used continuously, consistently and sustainably, because it is an indispensable thing, without which the land cannot remain in its essence (Carlowitz, 1713:105–106).

For Carlowitz, sustainability meant harvesting only as much wood as could regrow naturally. Where natural regeneration was insufficient, tree planting became the alternative, leading to the establishment of even-aged monocultures that shaped the appearance and management of forests well into the twentieth century—and, in many cases, to the present day (Lowood, 1990; Nocentini et al., 2021).

Beyond advocating long-term planning, Carlowitz explicitly linked forests to the essence or identity of the land—an essence threatened by unsustainable human use. In this sense, human activity ultimately shapes the nature of the forest. His concept of sustainability was embedded in a distinctly modern and dualistic worldview, in which humans acted as stewards of nature, managing it in accordance with their own needs. This approach aligned with the emerging logics of profit maximisation, economic liberalism, and industrialisation in the eighteenth and nineteenth centuries, all of which contributed to the homogenisation and rationalisation of forests (Puettmann et al., 2009:3–10).

Nevertheless, Carlowitz's concept provided a foundational "blueprint" for sustainability (Grober, 2013), which gained global prominence in the second half of the twentieth century through the work of the Club of Rome, Gro Harlem Brundtland, and, more recently, the United Nations Sustainable Development Goals. At the same time, growing concern about deforestation in tropical rainforests and about forest dieback (*Waldsterben*)—particularly in German-speaking Central Europe, where industrial emissions had visible local impacts—fuelled political and public debate about the potential loss of entire forest ecosystems (Metzger et al., 2007).

In response, forestry gradually moved away from an exclusive focus on wood and material production. In recent decades, under the banner of multifunctionality, increasing emphasis has been placed on forests' roles in recreation, carbon sequestration, biodiversity conservation, and protection against soil erosion, landslides, and avalanches. This broader recognition of the "ecosystem services" provided by forests (Brockerhoff et al., 2017) has also given rise to new forestry approaches that focus more strongly on preserving forest ecosystems as a whole. Accordingly, systems thinking has (re)gained prominence (Nocentini et al., 2021), and silviculture has become increasingly influenced by ecological science (Puettmann et al., 2009:ch. 4). Concepts such as diversity, resilience, and close-to-nature forestry have gained growing importance.

Viewed in historical perspective, forestry can thus be understood as having passed through a succession of paradigms and narratives: from mysticism and romanticism, through resource extractivism, to sustainability and systems thinking. Forestry practices have consistently reflected broader cultural, political, and economic conditions of particular times and places (Puettmann et al., 2009:ch. 1). Explaining these paradigms and the transitions between them in concrete case studies requires attention to multiple interacting dimensions, including biophysical, political-economic, and socio-cultural factors (Mather and Fairbairn, 2000; Edwards et al., 2022).

In recent decades, however, a new and previously underestimated factor has been driving profound changes in forestry: climate change. Traditionally, climatic conditions were treated as largely stable background parameters. Given the rapid pace of anthropogenic global warming, this assumption is no longer tenable. In the following sections, I therefore examine more closely the consequences of climate change for forests as ecosystems and for the practices of adapting forests to climate change under this emerging paradigm.

2.2 Forest management under climate change: A paradigm shift?

Global warming is expected to—and already does—have profound effects on forest ecosystems. One of the most immediate consequences of atmospheric warming is an increase in the frequency and intensity of extreme weather events, which can have devastating impacts on forests: high winds may topple entire stands, droughts can lead to widespread tree mortality, and heavy rainfall can destabilise forest soils. Moreover, such extremes often increase the likelihood of secondary disturbances, including wildfires and pest outbreaks (for overviews, see Allen et al., 2010; Millar and Stephenson, 2015; Seidl et al., 2017; Canelles et al., 2021; Forzieri et al., 2021; Miller et al., 2024).

Beyond these acute disturbances, climate change also exerts more gradual, long-term effects on forest dynamics. One critical trend is the anticipated shift of tree species distributions along altitudinal and latitudinal gradients. Thurm et al. (2018), for example, predict that the climatic suitability for many European tree species will move several hundred kilometres northward by the end of the century. Under both moderate and pessimistic climate scenarios, this would entail a loss of more than half of the potential distribution range for two key species in Europe—the Norway spruce (*Picea abies*) and the European beech (*Fagus sylvatica*). Similarly, Zischg et al. (2021) document significant upward shifts in vegetation belts in the Alps, signalling substantial changes in forest composition, particularly under more severe warming projections.

While these models indicate declining suitability for some species, others may benefit from a warming climate. In Europe, these include thermophilic species such as pedunculate oak (*Quercus robur*) and sessile oak (*Quercus petraea*), as well as non-native species like black locust

(*Robinia pseudoacacia*) and Douglas fir (*Pseudotsuga menziesii*) (Dyderski et al., 2018). Warmer conditions may increase tree species diversity in northern and high-elevation forests, while biodiversity may decline in southern or low-elevation stands (Buras and Menzel, 2018).

Climate change also affects trees at physiological, morphological, and even genetic levels. Warmer and drier conditions, combined with elevated atmospheric CO_2 concentrations, influence photosynthetic capacity and stress tolerance, potentially reducing resistance to pests and pathogens (Allen et al., 2010; Canelles et al., 2021). While some species may exhibit increased growth or foliage production under these conditions, others show declines in biomass accumulation (Vacek et al., 2023). Increasing scientific attention is therefore being paid to the genetic dimensions of climate adaptation (Alfaro et al., 2014; Neophytou et al., 2022). In this context, high intraspecific (genetic) diversity is considered crucial for adaptive capacity (Leites and Benito Garzón, 2023). Phenotypic plasticity—the ability of a given genotype to produce different morphological traits—also plays a central role in how trees respond to changing environmental conditions (Richter et al., 2012).

The overarching concern that unites these phenomena is whether forests can adapt rapidly enough to the unprecedented pace of anthropogenic climate change—whether through species migration, phenotypic plasticity, or evolutionary change (Lindner et al., 2010). This challenge is exacerbated by the long lifespans and slow reproductive cycles of trees (Keenan, 2015; Seidl et al., 2017; Vacek et al., 2023), which render forest ecosystems particularly vulnerable to rapid environmental shifts.

From this brief review, three key questions emerge as central to current debates on forest adaptation to climate change: (1) What might future forests look like? (2) How reliable is existing knowledge about these futures? (3) Which management strategies are recommended in light of these future scenarios?

Closely related is another pressing question: if forest ecosystems experience major disruption or collapse, can they recover—and if so, how quickly? In this context, the concept of *resilience* becomes central, referring to the capacity of ecosystems to absorb disturbance and recover essential functions (Rist and Moen, 2013; Millar and Stephenson, 2015).

The relevance of resilience is heightened by the high levels of uncertainty inherent in climate and forest models. These uncertainties stem both from the unpredictability of future greenhouse gas emissions—which are deeply entangled with global political processes—and from the challenges of downscaling global climate models to regional or local contexts (Wilby and Dessai, 2010). As Lindner et al. (2014:80) succinctly state:

> Despite intensive research over two decades, we cannot accurately forecast emissions and what the climate in Europe will be like later this century. It is unlikely that this situation will change anytime soon. [...] The challenge for forest management is how to cope with the observed and modelled trends and their associated uncertainties in adaptive

> forest management. Strategies that enhance ecosystem resilience are recommended, as are strategies which increase the flexibility of making future management changes, as required by realized climate change trends.

There is little reason to assume that this assessment has fundamentally changed in the decade since it was written. Uncertainty is unlikely to diminish—let alone disappear—through further research alone. As Messier et al. (2016:105) put it: "The only certainty today seems to be that tomorrow will bring changes and surprises for which we are ill prepared." Consequently, the challenge shifts away from long-term control and rationalisation of forest ecosystems towards more flexible and adaptive forms of management.

A range of practical approaches to forest adaptation is therefore currently debated within forest science. These include close-to-nature silviculture (Brang et al., 2014), assisted migration and the planting of native or non-native species or provenances (Lefèvre et al., 2013; Pötzelsberger et al., 2020), and strategies of non-management (Jandl et al., 2019). Each approach entails new risks and uncertainties—for example, ensuring that planted species are suited to both present and future climatic conditions (Wessely et al., 2024), or mitigating the risk that introduced species become invasive and threaten local biodiversity (Pötzelsberger et al., 2020; Wohlgemuth et al., 2022). Given the heterogeneity of forest ecosystems, there is no universal solution; nevertheless, forests must adapt in one way or another to these new conditions.

In response, a new paradigm has gained prominence: understanding forests as *complex adaptive systems* (Puettmann et al., 2009; Filotas et al., 2014; Messier et al., 2015; Messier et al., 2016; Nocentini et al., 2021), alongside the management approaches of adaptive management (Bolte et al., 2009; Rist et al., 2013; Spathelf et al., 2018) and planned adaptation (Kolström et al., 2011; Schoene and Bernier, 2012).

Complex adaptive systems theory traces back to Holling's (1973) concept of ecological resilience, which challenged the idea that ecosystem quality should be measured by stability alone. Instead, ecosystems are evaluated by their capacity to adapt and continue fulfilling essential functions under disturbance and novel conditions. This adaptive capacity arises from interactions among system components, producing emergent properties. While the ecosystem concept—dating back to the early twentieth century—is retained, its earlier orientation toward equilibrium and order is reversed in favour of diversity, self-organisation, non-linearity, and dynamism (Puettmann et al., 2009:110–111; Messier et al., 2015; Messier et al., 2016).

Forest management, from this perspective, should enhance adaptive capacity and resilience, moving away from command-and-control paradigms that emphasise efficiency, standardisation, and narrowly defined objectives (Puettmann et al., 2009). Even under changing conditions, forests should maintain their "essential functions" (Messier et al., 2015:373, see also Spathelf et al., 2018:2; Messier et al., 2019) such as timber production or biodiversity conservation. Rather than treating forests as rigid, teleological systems, this view conceptualises them as socio-ecological

systems whose future trajectories are inherently open (Nocentini et al., 2017).[6] Deterministic and reductionist perspectives are thus replaced by holistic and process-oriented ones (Messier et al., 2016).

In practice, this entails abandoning fixed end-states (such as maximising timber yield or biodiversity) and instead fostering diversity and interaction across ecological levels (genetic, population, community) and spatial scales. It also requires incorporating uncertainty, stakeholder knowledge, and reflexive learning into long-term decision-making (Messier et al., 2015; Messier et al., 2016). At the same time, ongoing scientific monitoring remains indispensable (Bolte et al., 2009:479; Kolström et al., 2011:974), even though key concepts such as *capacity* and *resilience* remain ambiguously defined and variably operationalised (Nikinmaa et al., 2020; Reinhold et al., 2025:3–4).

In sum, the response of complex adaptive systems theory to anthropogenic ecological change is to render the human dimension itself adaptive and dynamic. Adaptability is grounded in local diversity, reflexive learning, and continued trust in science's capacity to generate reliable—though fallible—knowledge. Despite its emphasis on uncertainty and change, the notion of a *system* still presupposes functional structures linking elements together.

Forest adaptation to climate change is therefore best understood as an ongoing, iterative process of monitoring, learning, and adjustment (Keenan, 2015:159). Adaptation—and thus change itself—has become the "new boundary condition for sustainable forest management and conservation" (Schoene and Bernier, 2012:12). At the same time, normative and ethical questions remain integral to all forest management strategies and cannot be sidestepped (Batavia and Nelson, 2016).[7] Rather than pursuing an ideal forest state, contemporary forest management increasingly involves navigating the epistemic, practical, and normative challenges of change itself. The absence of universal solutions is therefore accompanied by growing calls for local knowledge and context-specific approaches (Kolström et al., 2011:974; Keenan, 2015:158). In the following section, I examine how these challenges are addressed in social science research, focusing in particular on studies of stakeholder perceptions and practices.

[6] This openness is often conceptualised primarily in relation to social and human dimensions of socio-ecological systems, rather than as a property of non-human nature itself (see, for example, Messier et al., 2016:153).

[7] In some contexts, forest adaptation is discussed alongside efforts to enhance forests as carbon sinks and thereby contribute to climate change mitigation (e.g. the UNFCCC programme REDD+; see Schoene and Bernier, 2012). In this thesis, mitigation is addressed only insofar as it intersects with adaptation practices (see Section 8.2.2).

2.3 Reaction to this paradigm change: Studying the perception of change

In response to calls for a broader understanding of non-scientific perspectives on forest adaptation, a growing body of research has investigated how various stakeholders perceive and respond to climate change. Some studies examine general perceptions among forest stakeholders (Blennow et al., 2012; Yousefpour and Hanewinkel, 2015), while others focus on reactions to specific events, such as forest dieback (Deuffic et al., 2020; Brahic et al., 2022; Garms et al., 2024). Additional research explores stakeholder attitudes towards a range of forest management strategies—from general forestry practices (Hajjar and Kozak, 2015; Sousa-Silva et al., 2016; Ameztegui et al., 2018; Thomas et al., 2022) to more targeted interventions, including afforestation (Hazarika et al., 2021), assisted migration of species (Peterson St-Laurent et al., 2018), and the use of forest genetic resources (Vinceti et al., 2020).

Several general observations emerge from this literature. First, the term *stakeholder* is applied to a wide range of actors—not only forest managers, but also forest owners, public administrators, nursery operators, conservationists, and members of the general public. Strikingly absent from most of these studies, however, are scientists themselves, despite their central role in shaping diverging management recommendations (as discussed in the previous section). It appears, then, as if scientists do not "perceive" climate change at all, or as if their perceptions are assumed to be unproblematic and therefore not worthy of investigation.

Second, much of this literature relies on quantitative methodologies, particularly survey-based research—with Deuffic et al. (2020) being a notable exception. As a result, third, findings often take the form of general correlations that are subsequently interpreted in causal terms. For example, many studies suggest that psychological and cognitive factors—such as belief in climate change or personal experience (e.g. witnessing forest dieback)—determine recognition of and responses to climate change (Blennow and Persson, 2009; Blennow et al., 2012; Garms et al., 2024). Other studies emphasise that while stakeholders may acknowledge climate change, they often lack access to reliable, science-based information about its specific impacts on forests and about suitable adaptation strategies (Yousefpour and Hanewinkel, 2015; Sousa-Silva et al., 2016; Sousa-Silva et al., 2018; Vinceti et al., 2020; Hazarika et al., 2021).

A closer examination of how key concepts—especially *perception*, which features prominently—are defined (or left undefined) in this body of work is revealing. Most studies reviewed here do not provide a clear definition or theoretical framework for "perception" or related terms such as "attitudes," "views," "(local) knowledge," or "awareness." This conceptual vagueness is particularly evident in studies such as Blennow et al. (2012), Yousefpour and Hanewinkel (2015), Vinceti et al. (2020), and Hazarika et al. (2021), where perception is treated as a given and thus as analytically unproblematic.

Some authors attempt to define perception more explicitly, for example as "an active process of understanding, through which individuals construct their own version of reality" (Sousa-Silva et al., 2018:23). Yet this formulation remains vague. Is natural science not also engaged in constructing versions of reality—albeit in more standardised and systematic ways? How do these different "versions of reality" relate to one another, and how do they interact? Such questions point to deeper philosophical issues concerning the relationship between knowledge and reality—issues to which I will return later—but they also highlight a lack of analytical clarity in the existing literature.

Beyond these conceptual ambiguities, the methodological operationalisation of "perception" in many studies reveals several implicit assumptions. Blennow (2012), for example—similar to Sousa-Silva et al. (2018)—juxtaposes forest owners' responses to the question "Do you think that the climate is changing to such an extent that it will substantially affect your forest?" (with five graded answer options) with a binary question: "Have you adapted your forest management in response to climate change?" The resulting correlations—where a "yes" to the first question predicts a "yes" to the second—are interpreted causally: personal beliefs and experiences are taken to explain adaptation behaviour (Blennow, 2012:4).

The problem here is not that such results are unsurprising—or even that they verge on tautology—but that both knowledge of climate change and corresponding management practices are reduced to binary or quasi-binary categories. Perception is thus treated as a static, discrete variable that determines forest management practices (Hazarika et al., 2021:2). Some authors go further still, explicitly claiming that "perceptions determine actions" (Hoogstra, 2008:VIII), thereby reducing perception to the immediate cause of behaviour.

At the same time, perception itself is treated as a dependent variable that can be explained by various factors, including personal values, geographic location, forest characteristics, economic concerns, institutional trust, or gender (Spathelf et al., 2014; Hajjar and Kozak, 2015; Nelson et al., 2016; Deuffic et al., 2020; Thomas et al., 2022). As a result, both perception and practice are rendered as discrete, stable, and ultimately explainable phenomena. Individual motivations appear as fixed and homogeneous rather than evolving, reflexive, or potentially contradictory. Elements that fall outside this framework—such as uncertainty, ambiguity, social dynamics, or reflexivity—are largely neglected. What is studied, then, is not perception as a process, but a reified and timeless percept that has been predefined and rendered measurable.

Attempts to trace the causes of climate change adaptation to perception—and subsequently to identify the causes of perception itself—often lead to the conclusion that there is a "marked discrepancy between scientific knowledge about climate change and that of local stakeholders" (Yousefpour and Hanewinkel, 2015:274). The proposed remedy is typically improved communication of scientific knowledge, enhanced training for stakeholders, and policy adjustments

(Lindner et al., 2014:80; Sousa-Silva et al., 2018:27–29; Vinceti et al., 2020:1117; Hazarika et al., 2021:11).

In summary, while these studies seek to explain societal differences in perception, they ultimately aim to eliminate these differences in pursuit of a single, science-based truth. Non-scientific stakeholders' perceptions are framed as products of individual or social factors, whereas scientific knowledge is implicitly treated as objective and immune to such influences. This creates a fundamental epistemological divide: scientific knowledge is positioned as more legitimate, and management practices are expected to align with it. At the same time, this framing conceals the fact that all knowledge—including scientific knowledge—is partial, selective, and situated (Brown and Damery, 2009:85). Within this linear, one-way model of knowledge transfer, scientists are encouraged to communicate more effectively, while practitioners and the public are expected to become more receptive (for critiques of this outdated model of science communication, see Hulme, 2009:217–218; Beck, 2011).

Such a mechanistic model—where perception is explained by a set of variables and, in turn, determines adaptive practice—ultimately seeks to identify general laws of social behaviour. Moreover, it reduces social perception to the aggregate of individual perceptions. This risks portraying human subjects as passive and reactive, diminishing their agency and overlooking the dynamic, reciprocal relationships between individuals and their social and environmental contexts. How people perceive and respond to climate change is far more complex. As Koning, Turnhout et al. (2014) show, forest practitioners often acknowledge the importance of climate change but remain critical of the usefulness of available scientific knowledge, instead relying heavily on knowledge embedded in management practice.

In this sense, perception-based approaches stand in tension with the recognition of diverse local knowledges and with an understanding of knowledge-making as a dynamic, evolving, and reflexive process—key principles of the contemporary forestry paradigm informed by complex adaptive systems theory. From this perspective, perception and practice should not be treated as independent or dependent variables—that is, as fixed, static, and quantitatively measurable units—but as processes that unfold over time. As discussed in the previous section, even within scientific communities there is substantial uncertainty about how climate change will progress and how forest ecosystems will respond, particularly at local scales. This challenges the idea of science as the sole repository of objective truth and instead calls for a high degree of scientific reflexivity.

This, in turn, calls for a re-examination of the interface between forest science, management, and policy (see e.g. Detten et al., 2013; Koning, Turnhout et al., 2014; Lauser, 2024). In the following section, I therefore turn to emerging empirical and conceptual work on uncertainty in forestry. This literature helps identify the key challenges that uncertainty poses for understanding—and empirically analysing—the process of adapting forests to climate change.

2.4 The paradox of uncertainty: An attempt to rethink FACC

The previous section highlighted a certain incoherence between the theory of complex adaptive systems—emphasising socio-ecological holism, reflexive learning, and the continuous development of new management practices—and a concurrent trend toward reductionist explanations that rely on fixed, unchangeable factors to account for stakeholder perceptions and corresponding management strategies. In light of this tension, it is useful to return to the very element that serves as a starting point for complex adaptive systems theory while simultaneously resisting such fixity—namely, uncertainty. In what follows, I examine in greater depth how uncertainty is conceptualised, discussed, and empirically investigated in the context of FACC.

An example of such empirical research is provided by Hoogstra and Schanz (2008; see also Hoogstra, 2008). In a comparative study of uncertainty in forestry and agriculture, they argue that uncertainty is not a marginal feature but a central structural characteristic of forest management, particularly under conditions of climate change. Unpredictability and surprise, they suggest, are intrinsic to forestry and may serve as sources of opportunity and innovation. Yet this does not imply that uncertainty should be ignored. On the contrary, because forestry involves long-term decisions with potentially far-reaching consequences, uncertainty must be both managed and recognised as a driver of change and innovation. Their conclusion is thus twofold: the challenge lies in reducing uncertainty while simultaneously increasing "degrees of freedom" to foster an open and adaptive future (Hoogstra and Schanz, 2008:322).

In a similar vein, Lawrence (2017), in her study of UK forest professionals, calls for a shift away from a narrow focus on practitioners' "attitudes" and "beliefs" toward a deeper understanding of their actual practices. She finds that professionals often integrate both deterministic and indeterministic elements, balancing control with contingency. This multiplicity of approaches reflects adaptive strategies developed in response to complex and shifting environmental conditions. She thereby critiques the dominant command-and-control paradigm in forest management.

Building on related insights, Lidskog and Löfmarck (2015), drawing on qualitative interviews with Swedish forestry professionals, develop an expanded framework for understanding uncertainty. They distinguish four key types: *cognitive uncertainty* (stemming from a lack of knowledge), *strategic uncertainty* (arising from conflicting interests), *institutional uncertainty* (due to a lack of coordination), and *normative uncertainty* (rooted in incoherent or competing values). Their findings suggest that practitioners struggle particularly with the non-cognitive forms—strategic, institutional, and normative—highlighting that uncertainty in practice is not merely a cognitive or epistemic issue but is deeply shaped by the broader social context in which it is embedded.

In this regard, it is helpful to clarify the term *uncertainty* itself. For the context of FACC, Detten (2011:452), referring to Wynne (1992:114), differentiates between several closely related concepts: *risk* (where the parameters and behaviour of a system are well known and the probabilities of outcomes can be quantified), *uncertainty* (a lack of knowledge about the probability distributions of known parameters), *ignorance* (a lack of awareness of the existence of certain parameters), and *indeterminacy* (the human contribution to the openness of socio-ecological systems through contingent decisions). Here, contingency is defined as the "state of being open to various possible decisions" (Detten, 2011:452). Accordingly, uncertainty and ignorance pertain primarily to the level of knowledge, whereas indeterminacy and contingency refer to the systemic state under investigation.[8]

In the following, I focus less on the notion of risk and more on those elements which, according to these definitions, are not—or cannot be—measured in a quantifiable manner. In the case of FACC, all these elements share a common feature: they stand in tension with prevailing social demands for sustainable, long-term forest management. However, as Detten argues in a series of papers (Detten, 2011; Detten and Hanewinkel, 2017; Detten, 2018), uncertainty has always been part of forest management. Yet he does not interpret uncertainty as implying a lack of knowledge among practitioners. Rather, forest management entails reflective engagement with the fact that outcomes frequently diverge from expectations. Like Lawrence (2017), Detten therefore advocates abandoning planned adaptive management approaches rooted in classical understandings of sustainability as the maintenance of a predefined forest state.

It should also be recalled that the question of how forests are—and should be—managed sustainably is itself subject to intense socio-political debate (Winkel et al., 2011; Mack et al., 2023). The idea of sustainability may intersect, compete, or blend with other discourses governing forest management, such as ecological modernisation, pro- or degrowth, neoliberal market logics, and deregulation (Arts et al., 2010; Pülzl et al., 2024). Particularly in relation to climate change, "sustainable forest management" is framed in multiple—and sometimes conflicting—ways, for example in terms of nature conservation or long-term timber production (Storch and Winkel, 2013). Moreover, while debates at higher institutional levels, such as the European Union, may be polarised and politicised, climate change itself appears largely accepted as a crucial element at the local level of forest practice (Koning, Winkel et al., 2014).

Thus, not only are ongoing biophysical changes complex and unpredictable, and knowledge about them uncertain; the social contexts in which forestry is embedded are themselves unstable, heterogeneous, and subject to transformation. In this light, as Detten (2011:453) observes,

[8] Nielsen and Ulanowicz (2011) propose the notion of *ontic openness* to capture systemic indeterminacy, which they understand as rooted in thermodynamic entropy and, at the same time, as a necessary condition for biological development and thus change. By contrast, uncertainty and ignorance could be described as forms of *epistemic openness*. I return to—and critically discuss—this distinction between ontology and epistemology in Chapter 3.

two different—and at times contradictory—necessities currently shape forest practice: the need "to act against the background of ecological complexity and uncertainty," and the need to "legitimate [actions] against a background of ever-changing social demands on forestry."

From this perspective, it seems promising to rethink the issue of uncertainty. In everyday language, uncertainty—understood as the absence of knowledge about the outcomes of processes in reality—can be seen as arising from at least three elements: the complexity and indeterminate character of the biophysical world; the absence of confident explanatory knowledge about it; and the human necessity to act within this world. The latter both presupposes the openness of the world and contributes to it, since human action itself is indeterminate. Rather than treating uncertainty as an obstacle to be removed through the accumulation of scientific knowledge, it may therefore be more fruitful to regard it as a conceptual and practical starting point for rethinking the relationship between knowledge and adaptive practice in a world undergoing ecological change.

The key to this rethinking may lie in understanding uncertainty neither as something simply "out there" in the world nor as merely a problem of inadequate knowledge, but as "a property of *relations* between what is known and who is doing the knowing" (Scoones and Stirling, 2020:11, emphasis added). From this perspective, uncertainty highlights that knowledge is never absolute but—following the Popperian tradition—always open to falsification. Uncertainty is thus a necessary condition of knowledge itself: "Without limits [of knowledge] we would have to incorporate life, the universe and everything into every knowledge claim we make—and that is not possible" (Cilliers, 2005:263–264). Accordingly, uncertainty should neither be treated as a temporary problem of incomplete information that can simply be resolved through more data (Detten, 2011:456) nor accepted as an unavoidable fate that precludes meaningful strategies for dealing with it.

This discussion echoes a philosophical puzzle from Plato, often referred to as Meno's paradox:

> A man cannot inquire either about that which he knows, or about that which he does not know; for assuming he knows, he has no need to inquire; nor can he inquire about that which he does not know, for he does not know what he is to inquire about (quoted in Bhaskar, 2008:260).

A similar paradox applies to uncertainty: one cannot be uncertain about what one fully knows, nor about what one does not know at all. Uncertainty thus emerges from a second-order position that allows reflection upon one's own knowledge. Accordingly, there is no binary logic separating certain from uncertain knowledge (Jasanoff, 2007). From this perspective, the famous "unknown unknowns"—or deep uncertainties—lose centrality, since by definition they cannot be anticipated; attempting to incorporate them fully into decision-making would risk paralysing action in the face of everything that might occur (Thompson, 2022:9–10).

At the same time, this paradox can be addressed by rejecting strict dichotomies between opposites such as knowledge and uncertainty, or reality and knowledge. Rather than being mutually exclusive, they are always already intertwined within the ongoing process of apprehending and

inhabiting a complex socio-ecological world. While such opposites represent different aspects of the same phenomenon, both are present in every human act. The contributions cited above suggest that the absence of certainty is not necessarily a deficiency to be corrected but a condition of human agency and freedom. Uncertainty is not only "endemic to scientific knowledge" (Wynne, 1992:115) and a "condition of knowledge itself" (Scoones and Stirling, 2020:4); it is also a precondition for free human action. If everything were predetermined—and that determination fully known—how could choice be possible? For forestry, it can therefore be said that while "uncertainty and a lack of knowledge are an objective fact," they also "lead to freedom of choice, since the outcome is not controllable and its consequences affect subsequent generations" (Detten and Hanewinkel, 2017:64).

The ultimate paradox of uncertainty, then, lies not merely in its omnipresence in science and everyday life. Rather, it resides in the fact that human beings seek precise, predictive knowledge in order to intervene effectively in the world, while simultaneously wishing that this world remain open to intervention—a condition that presupposes that it cannot be fully determined or predicted.

Uncertainty is therefore inseparable from the question of practice: even in the face of uncertainty about the future, it is impossible not to decide. Because practice always unfolds within a social context, ways of dealing with uncertainty are inherently ethical and political questions. In light of the considerable uncertainty surrounding climate models, the physical geographers Harman et al. (1998) capture the irony of classical scientific rationality—its tendency to call for ever more knowledge—of always accumulating more knowledge in asking: "When, if ever, are we justified to act in spite of [...] uncertainty?" This suggests that uncertainty, like knowledge, is not a neutral concept but is shaped by socio-cultural norms and political framings (Wynne, 1992; Proctor, 2008; Scoones and Stirling, 2020). Within the current FACC literature, this normativity often surfaces in statements such as "we need to know more," or "because we cannot know X, we should do Y" (see, in this regard, the calls mentioned in the previous section for better integration of science into forest practice).

What the discourse on uncertainty and complex adaptive systems in the context of FACC perhaps reveals most clearly is a reflexive awareness: science—modernity's principal instrument for understanding and controlling the world—encounters inherent limits. Uncertainty reminds us that not everything is predetermined and that the future remains open. The central question, then, is how this openness can be engaged in practice.

2.5 Beyond positivism and constructivism: Toward a third way in knowledge and practice

The paradox and question raised at the end of the previous section—concerning the tension and interplay between knowledge and uncertainty, and, correspondingly, on a systemic level between determinedness and openness—form the point of departure for the present study. This paradox is particularly significant in the case of FACC, where biophysical changes pose novel and urgent challenges for forest management. New knowledge is being sought in order to respond effectively. Yet waiting for complete and accurate understanding—much of which remains emergent—risks missing opportunities for timely intervention.

In this light, three key axes emerge along which the uncertainty–practice interplay can be addressed in rethinking FACC. First, there is the deep interwovenness of forest ecosystems—components of the biophysical world—with human societies. As the frequently invoked concept of socio-ecological systems shows, neither can be understood as radically separate or independent from the other. This is evident not only in the global context of anthropogenic climate change, but also in more local and historical contexts. As shown in Section 2.1, humans have intervened in forests for centuries, significantly shaping their current conditions. In this process, both seemingly secure knowledge and long-term planning, as well as unexpected developments, have played crucial roles. While humans are clearly capable of understanding aspects of nature that enable intentional intervention, nature can also resist or redirect these efforts in unforeseen ways.

These insights suggest that acknowledging this interconnectedness should not lead to treating "society" and "nature" as homogeneous—or as dichotomously opposed—entities. What therefore deserves more attention in the field of FACC is this co-evolving relationship between human and non-human elements, and how it can be conceptualised.

Second, the element of change is omnipresent in this field. As seen in Section 2.2, the anthropogenic influence on the global climate system affects and interacts with different levels of forests—genes, organisms, species, and ecosystems. This calls for conceiving of forests as complex systems that are open to change, where concrete phenomena cannot be reduced to simple causal laws aimed at prediction. Deterministic views of nature, society, and their interrelations are therefore of limited use for thinking about change in this context.

Yet rejecting determinism too often leads to approaches that lean toward pure randomness and contingency. As also shown in Section 2.2, this is not the case in the field of FACC: there are clear indications of the directions in which climatic conditions are evolving, and of how forests are responding to these changes. Moreover, forest management follows certain goals that shape the practice of individual forest managers and are themselves shaped by broader social requirements. This suggests the need to rethink causality and system thinking—toward concepts that

navigate between, or even beyond, the opposites of determinism and contingency. Within such a reimagined framework, the materiality of biophysical nature, the agency of individuals, and the structuring influence of social systems all deserve attention.

Third, alongside the notion of change comes the element of temporality. Time plays a key role in several respects within FACC. Forests have adapted over centuries to site-specific climatic conditions, and current global warming is altering these conditions over just a few decades. A similar clash of timeframes applies to forest management: although management practices draw on centuries of accumulated knowledge and take a long-term orientation, decisions must be made in the present, under its specific constraints. These constraints are not only temporal but also contextual—embedded in the social, cultural, and institutional frameworks of the present moment.

In this sense, knowledge is limited and socially constructed, insofar as it depends on—and is constrained by—human actors situated within specific contexts. Yet knowledge also refers to, and practice engages with, something that exceeds any social or human framing: the material and changing character of biophysical nature itself. The problem of temporality emerges precisely through this interplay: knowledge is a changing process that seeks to grasp something that is itself changing, while simultaneously shaping the practices through which humans aim to intervene in the world.

These three dimensions—human–nature interwovenness, change, and temporality—ultimately revolve around biophysical reality, knowledge, and praxis, and the relationships among them. This invites deeper reflection on what it means to generate and possess knowledge about nature or reality. This thesis builds on the argument that any meaningful understanding of FACC and its key issues requires a deeper conceptualisation of the relationship between reality, knowledge, and human agency. This requires, at once, an analytical distinction between these elements and a framework of coherent identity—that is, thinking them together.

With knowledge functioning as the hinge that mediates human practice and contextual reality, it is crucial to recognise that no single, universally accepted theory of knowledge exists—whether in the sciences or in broader inquiries into biophysical reality (Yearley, 2005; Chalmers, 2013). Positivism, long the dominant epistemological paradigm in science, still exerts influence. It posits a mind-independent reality structured by regularities that can be observed neutrally by rational subjects. From these observations, general causal laws can be inferred—universal principles that explain and predict how events unfold in time and space (Keat and Urry, 2010:7–19). In this view, knowledge is "true" when it corresponds to reality and enables prediction.

However, this correspondence theory of truth has been widely criticised—especially its assumptions about objectivity and the idea that knowledge directly reflects reality. Critics argue that knowledge is socially constructed: shaped through the act of knowing, which is itself conditioned by social and cultural contexts (Golinski, 2005). Constructivist perspectives contend that

knowledge is not only a product of socially embedded human actors, but also a reflection of societal forces—power, discourse, institutions. In this regard, the social production of knowledge is deeply entangled with the production of social order (Jasanoff, 2004). Knowledge, truth, or reality is what is conventionally accepted as such—either because it coheres with other beliefs or because it "works" pragmatically. In this view, knowledge corresponds not to an external reality, but to the social context in which it is produced. This insight has strongly influenced literature on the social construction of nature, which argues that "nature" is not simply given, but constructed (Cronon, 1996; Castree, 2014; Robbins et al., 2014:119–137).

Yet this constructivist view has also faced compelling critiques, many of which focus on the marginalisation of the biophysical or material world in such accounts of knowledge—and, ultimately, of society. This has led some authors to abandon the distinction between (material) nature and (ideational) culture altogether (most prominently Latour, 1993). Maintaining a postmodern or post-structuralist impulse to reject metanarratives (here, especially anthropocentrism), these approaches treat non-human actors as symmetrical with human beings in shaping the social world. In this framework, reality is not pre-given but emerges through assemblages or networks of diverse actors. Socio-cultural differences do not merely reflect divergent interpretations of a shared world; they constitute entirely different worlds (Carrithers et al., 2010; Viveiros de Castro, 2015; and on forests, Kohn, 2013). This conception of an ever-changing flux not only negates any notion of biophysical or social structures and causal powers, but also the fundamental distinction between knowledge and reality.[9] By collapsing this distinction, such approaches come strikingly close to the positivist-empiricist idea that the world can be accessed "as it is," thereby again conflating knowledge and reality.

Another line of critique targets precisely this collapse of the distinction between knowledge and reality. For instance, Ian Hacking (1999:30), responding to constructivist accounts of particle physics, asserts: "It is the idea [or knowledge] of quarks, rather than quarks, which is the social construction. […] Quarks, the objects themselves, are not constructs." Similarly, Elder-Vass (2012) affirms the existence of a reality independent of our (constructed) knowledge of it. In the context of climate change, Malm (2018) warns that treating nature as a social construct would render extreme droughts, floods, or storms mere "ideas," thereby obscuring their material consequences for those affected. Hence, these authors accept the existence of knowledge and a (material, biophysical, or otherwise characterised) world beyond it.[10]

[9] For concise formulations of this position, see e.g. Henare et al. (2007:13): "concepts and things are just one and the same"; or Latour (2017:70): "existence and signification are synonyms".

[10] I prefer the term "biophysical" to "material." Especially in relation to the biological world—which is central to FACC—it is problematic to reduce it to materiality alone, as it encompasses not only physical laws (e.g., gravity) and chemical processes (e.g., photosynthesis), but also organismic and evolutionary change shaped by interactions among living beings (e.g., pollinator–plant relationships).

From the discussion of FACC so far, it is evident that neither positivist nor radical constructivist (or poststructuralist, broadly speaking) perspectives are satisfactory. Uncertainties in climate modelling and unpredictable forest responses highlight the limits of reliable knowledge corresponding neatly to an external world of nature. Moreover, the multiplicity of perspectives on forests shows that epistemic differences are real. However, concluding from this that "anything goes"—or that there is nothing beyond knowledge claims—is equally misguided. Uncertainty, learning, and epistemic pluralism do not imply the absence of a reality prior to and beyond them; rather, they are fallible moments in a process of grasping, relating, and referring to reality. They point to the need for an understanding that recognises knowledge as neither identical to nor entirely separate from reality.

Yet FACC is not only about knowledge. There is a biophysical system undergoing transformation, regardless of whether it is known. The trajectory of this change depends both on natural dynamics and on how humans materially interact with forests—a relationship mediated by knowledge and social demands. Humans can indeed shape the future anthropogenically, and knowledge about the future can feed back into its eventual material outcome; this complicates any overly rigid separation between knowledge and reality. But the opposite conclusion—namely, that humans can do anything with forests, and that reality and knowledge are therefore the same—is equally misleading. Structural constraints in nature persist independently of humans and their knowledge of them: trees, for example, have genetically defined capacities (e.g., photosynthesis), while humans retain the ability to cut or plant them. In this sense, both the biophysical and the social domains are marked not only by change, but also by enduring structures.

What is needed, then, is a framework that integrates these interdependent but separable elements: biophysical reality, the constructed nature of knowledge, the processual character of change, and the role of contingency and causality. In the following chapter, I introduce critical realism as a philosophical approach that addresses these concerns—offering a "third way" beyond positivism and constructivism. It is a framework that is both logically robust and conceptually flexible—well suited to the complexities of FACC.

Chapter 3: Critical realism: Theoretical foundations for understanding FACC

In the previous chapter, I identified the relationship between biophysical reality, knowledge about that reality, and individual and social agency as the central problematic shaping the field of forest adaptation to climate change (FACC). In this chapter, I introduce critical realism as a philosophical approach capable of addressing these interrelated dimensions in a coherent and non-reductionist way.

Critical realism (hereafter CR) was initially developed by Roy Bhaskar (1944–2014) as a philosophy of natural science (Bhaskar, 1978) and subsequently expanded through several phases. The first phase combined a realist philosophy of science with a theory of society and social scientific explanation (Bhaskar, 1998), further elaborated by scholars such as Sayer (1992, 2000), Archer (1995, 2000, 2003), and Elder-Vass (2011, 2012). The second phase developed a dialectical and explicitly emancipatory orientation, focusing on absence, contradiction, and human freedom (notably Bhaskar, 2008, 2010). A third phase turned toward metaphysics and spirituality (Bhaskar, 2012a, 2012b). A fourth, ongoing phase emphasises empirical applications of CR across a wide range of substantive fields.

For the purposes of this study, which centres on human–nature relations in the context of FACC, I draw primarily on the first two phases of CR. Accordingly, this chapter outlines the core contours of first-phase critical realist metatheory. Section 3.1 introduces CR's account of reality and knowledge, focusing on ontological realism and epistemological relativism in relation to biophysical nature. Section 3.2 then turns to CR's account of society, agency, and normativity. Together, these sections establish the philosophical foundations for the conceptual framework developed in Chapter 4, which builds explicitly on Bhaskar's dialectical thought. In terms of empirical orientation, the present study as a whole aligns with the fourth phase, which emphasises application to concrete social and environmental problems.

As its name suggests, CR affirms realism: the existence of a reality that does not depend on human cognition. At the same time, this reality is not conceived as a closed or static totality, but rather as "a potentially infinite totality, of which we know something but not how much" (Bhaskar, 2008:14). Although "everything is real and there is nothing which is not real," reality is internally differentiated and stratified: "there are differentiations within the real" (Bhaskar, 2012a:37). To conceptualise this reality, Bhaskar introduces two fundamental analytical distinctions. The first is between the intransitive dimension of reality (the world itself) and the transitive dimension (human knowledge of the world), corresponding broadly to ontology and epistemology. The second is between the intrinsic and extrinsic aspects of human subjectivity, referring to reflexive, intentional capacities on the one hand and historically and socially conditioned features on the other.

This chapter introduces the first distinction in Section 3.1, with a focus on natural science and knowledge of biophysical reality, and the second in Section 3.2, with a focus on society, agency, and values. Section 3.3 then brings these insights together in relation to FACC, outlining what a critical realist perspective contributes to rethinking the key problems identified at the end of Chapter 2. The chapter concludes by proposing a critical realist heuristic for analysing FACC.

3.1 Reality and knowledge in critical realism

This section introduces two key pillars of critical realism: ontological realism (Section 3.1.1) and epistemological relativism (Section 3.1.2), understood as its theories of reality and knowledge. Section 3.1.3 subsequently examines how these two pillars relate to one another, highlighting their inseparable connection.

3.1.1 Ontological realism: Depth, causality, and emergence

Bhaskar's first major work, *A Realist Theory of Science* (Bhaskar, 1978), was written to articulate an alternative philosophy of (natural) science capable of overcoming the limitations of empiricism and, in particular, its positivist variants. At the core of this project lies Bhaskar's critique of what he terms the *epistemic fallacy*: the "metaphysical dogma [...] that statements about being can always be transposed into statements about our knowledge of being" (Bhaskar, 1978:16). Empiricism, in this sense, maintains that knowledge is derived exclusively from experience, whether directly or indirectly (for instance, through instruments such as microscopes). On this view, there is no world that exceeds human experience—and hence no reality beyond what can, in principle, be known. David Hume, as a central figure of empiricism, argued accordingly that the constant conjunction of empirically observed events (e.g. an object falling when dropped) provides the basis for generalisations in the form of causal laws, which are taken to constitute the structure of the world.

Bhaskar rejects this claim by pointing out that such regularities only obtain within *closed systems*—that is, settings that are predefined or artificially constructed, such as laboratory experiments. The real world, by contrast, is neither finite nor closed; it is open, complex, and independent of the knower. Consequently, there is no absolute guarantee that a dropped object will always fall in exactly the same way. By conflating knowledge with reality, empiricism effectively denies the existence of causes that are not directly observable. In doing so, it collapses being into what can be known, and treats what is unknowable as non-existent. This "systematic dissolution of the idea of a world [...] independent of but investigated by science" (Bhaskar, 1978:36–37) ultimately leads to an idealist position—ironically contradicting empiricism's and positivism's own materialist aspirations.

Bhaskar's critique of empiricism on grounds of internal inconsistency, however, is only the starting point. His more fundamental argument for an independent reality is transcendental in form and deceptively simple: "It is not necessary that science occurs. [...] But given that science does or could occur, the world must be a certain way. Thus [...] the world is structured and differentiated" (Bhaskar, 1978:29). In other words, while a world without science is conceivable, science without a world that exists independently of it is not. The existence of a mind-independent world is therefore a necessary condition for the possibility of scientific practice.

Moreover, the world is not merely independent of science but also stratified and deep. While some events can be observed, others cannot, and behind observable events lie multiple causal mechanisms that generate them. Bhaskar (1978:56–57) distinguishes three domains of reality: the *empirical*, comprising events that are or can be observed; the *actual*, encompassing all events that occur, whether observed or not; and the *real*, which consists of the deeper causal mechanisms that generate events. The real encompasses but is not exhausted by the actual, which in turn encompasses but is not exhausted by the empirical.

The distinction between the real and the actual allows for a non-deterministic conception of events. Any given event results from the interplay of multiple causal powers operating at different levels of reality. A forest ecosystem, for example, can be explained partly by biological processes, which are grounded in biochemical mechanisms, themselves dependent on molecular and physical interactions. This layered explanation does not imply reductionism: higher-order systems, or "wholes," possess *emergent causal powers* that are not reducible to those of their constituent parts. A forest, therefore, is more than the sum of its trees.

Emergence refers to the process through which particular causal powers arise from the interactions of lower-level components within a system (Bhaskar, 1978:113). It concerns the relational organisation of parts, rather than the parts taken in isolation. While causal powers themselves unfold diachronically over time by generating sequences of events, their emergence occurs synchronically—at specific moments in time and space where elements are related in particular ways (Elder-Vass, 2005:321).

This account of causality does not entail that future events are predetermined. Rather, it explicitly separates causality from determinism: just "because an event was caused to happen" does not mean that "it was bound to happen before it was caused" (Bhaskar, 2003:154). Once an event has occurred, it is determined and irreversible—there is no "backwards causation" (Bhaskar, 2008:71) capable of undoing it. Thus, while a cause need not produce an effect, every effect, in the form of an event, must have one or more causes. This distinction sharpens the conceptual difference between explanation and prediction, not only in their temporal orientation (retrospective versus prospective) but also in their respective epistemic status.

This framework accommodates change, instability, and complexity in the actual world. Although the world may often appear chaotic, Bhaskar emphasises that "it is not completely chaotic and can be grasped at a certain level" (Bhaskar in Singh et al., 2020:70). Rather than abandoning causality, this view resonates with the probabilistic insights of quantum theory: the world may be understood as "a sea of unrealized *potentia*, waiting for a trigger to actualize them" (Porpora, 2000:39, his emphasis). Causal powers thus exist as *potentialities*, regardless of whether they are activated. A plant seed, for instance, may lie dormant in soil for years, yet it retains the causal power to germinate under appropriate conditions.

Both the emergence and the activation of causal powers depend on context—that is, on their relations with other causal powers and entities. Events are therefore always temporally and spatially situated (Mingers, 2011:318). A seed begins to germinate when other causal powers, such as water and light, are present and interact with it. I will return to this crucial theme of context and relationality later in this work.

The interaction of diverse causal powers gives rise to "the flux of phenomena that constitute the actual states and happenings of the world" (Bhaskar, 1978:47). Importantly, the constant conjunction of events, as proposed by Hume, does not generate causal laws; rather, "events are caused by contingent conjunctures of causal mechanisms" (Decoteau, 2018:90). The same causal power may produce different outcomes depending on how it interacts with others. Apparent randomness and contingency are therefore not signs of the absence of causality, but expressions of its complexity. Contingency is shifted from the level of events to the level of their causal conditions.

Applied to the case of FACC, Bhaskar's ontology affirms that causality is real and operative within biophysical nature, while simultaneously recognising the openness of the world. Reality unfolds across time and space and may develop in ways that exceed any observer's anticipation. This position is commonly referred to as *ontological* or *transcendental realism*.

3.1.2 Epistemological relativism: Knowledge, fallibility, and context

As established in the previous section, the existence of a world independent of human cognition is a necessary condition for the possibility of science or knowledge. While a world could exist without science, science cannot exist without a world. Yet this condition alone does not explain why science—described by Bhaskar (1978:39) as an "historical accident"—actually emerges, nor how scientific knowledge is produced. The nature of knowledge therefore requires further analysis.

Bhaskar identifies two fundamental features of science that are crucial for understanding knowledge: first, that science is a human activity involving labour; and second, that scientific knowledge is fallible. The first point highlights that knowledge is not produced in a social vacuum

but emerges from situated human practices. This becomes evident in the paradigmatic case of the scientific experiment. Under experimentally closed conditions—that is, through the deliberate control of variables—scientists can reproduce a sequence of events and thereby generate knowledge about particular causal powers. Whether such knowledge can be transferred to open, non-experimental contexts is a further question. Nevertheless, because experiments rely on instruments, techniques, skills, and coordinated human effort, Bhaskar (1978:21) characterises scientific knowledge as "a social product much like any other, which is no more independent of its production and the men who produce it than motor cars, armchairs or books [and] which has its own craftsmen, technicians, publicists, standards and skills".

Scientific experiments thus demonstrate that it is possible to produce knowledge *about* causal mechanisms in the world. For example, depriving a plant of water over several days may lead to its death, indicating a causal relationship between water availability and plant vitality. However, such regularities are rarely encountered in real-world, open systems. Weather conditions change daily, and even two plants of the same species growing side by side may differ considerably in form and development. This is because reality is open and shaped by the contingent interplay of multiple causal powers, each contributing to particular events. Even when regular patterns are observed—such as the daily sunrise—it can never be known with certainty whether they arise from the same causal mechanisms or will continue unchanged. This is the well-known problem of induction. Scientific observers must therefore interpret events by relating them to prior knowledge of other events and hypothesised mechanisms. Scientific knowledge always builds upon already existing knowledge.

Accordingly, while causal powers in the biophysical world can be accessed through sense-experience and constrain what can plausibly be said about them, they do not determine scientific knowledge. This is how explanatory theories are formed: the theory of gravity explains why objects fall; the theory of evolution explains biological diversity. Pure descriptions of isolated events remain idiographic and limited. Explanatory knowledge is more powerful insofar as it links observable phenomena to the causal mechanisms that generate them. Yet because such mechanisms cannot be perceived directly and must be inferred from their effects, explanatory knowledge necessarily involves interpretation.

This interpretative dimension points to the second defining feature of scientific knowledge: its fallibility. The history of science is marked by the revision and rejection of once-dominant theories, such as the Ptolemaic system, Newtonian mechanics, or Lamarckian evolution. Bhaskar defines a scientific theory as "a model with existential commitment; that is, a model conceived, and meant to be taken, as true" (Bhaskar, 1978:192). However, the choice between competing theories is never based on empirical content alone. It also relies on criteria of justification—such as coherence, explanatory power, or simplicity—that are external to the theory itself and thus irreducibly metaphysical in character (Bhaskar, 1978:192–193).

What are commonly referred to as "facts" are therefore not neutral givens but theory-mediated interpretations of phenomena: "what is explained is never the 'pure' phenomena, but always phenomena read in a certain way" (Bhaskar, 1978:190). Theoretical frameworks shape what is observed and how it is understood. The knowing subject thus functions as a conceptual "bottleneck" (Hannah, 1999:19), through which the world is filtered by existing categories and concepts. As Bhaskar (1978:22) puts it, "we cannot imagine the production of knowledge save from, and by means of, knowledge-like materials. Knowledge depends upon knowledge-like antecedents". Knowledge is therefore concept- and theory-dependent, though crucially not theory-determined.

Importantly, the theory-ladenness of knowledge and the artificiality of experimental closure do not imply that causal mechanisms themselves are artefacts of theory or experiment. As Bhaskar (1978:47) insists, they are neither artificial constructs nor Platonic abstractions. They can become manifest in experience, yet they are not exhausted by it: "We are not imprisoned in caves, either of our own or of nature's making. We are not doomed to ignorance. But neither are we spontaneously free" (ibid.).

In sum, two key conclusions follow. First, knowledge is a human—and therefore social—product. Second, it is fallible and subject to historical change. Together, these claims constitute what Bhaskar terms *epistemological relativism*. Knowledge is distinct from the reality it seeks to describe[11] and always emerges within a broader social, historical, and theoretical context.

3.1.3 Relating ontological realism and epistemological relativism: The dialectic of truth

If knowledge is necessarily thought, and material reality exists apart from thought, how is it possible for a thinking mind to grasp something that lies beyond—and thus transcends—itself? In other words, how can epistemological relativism and ontological realism be brought into relation? For Bhaskar, this problem arises only if thought, knowledge, and theory are conceived as radically separate from reality, as much of modern philosophy has done—most notably in Kant's division between the knowable phenomenal world and the unknowable noumenal realm. Bhaskar's ambition is to resolve what he calls the "central paradox of science": that "men in their social activity

[11] This distinction between knowledge as a socially produced phenomenon and the reality it refers to marks a central point of divergence between CR and influential strands of Science and Technology Studies (STS). From a critical realist perspective, it is untenable to claim that entities such as microbial ferments "did not exist" prior to their scientific discovery, as Latour (1999:145) suggests. As Bhaskar (1978:39) puts it: "Knowledge follows existence, in logic and in time; and any philosophical position which explicitly or implicitly denies this has got things upside down." CR thus rejects both naïve realism and strong social constructivism, maintaining instead the ontological independence of the world alongside the social production and fallibility of knowledge about it.

produce knowledge which is a social product much like any other [... and] that knowledge is *'of'* things which are not produced by men at all" (Bhaskar, 1978:21, his emphasis).

The link uniting these two "sides" of knowledge lies in Bhaskar's conception of truth:

> A proposition is true if and only if the state of affairs that it expresses (describes) is real. But propositions cannot be compared with states of affairs; their relationship cannot be described as one of correspondence. Philosophers have wanted a theory of truth to provide a criterion or stamp of knowledge. But no such stamp is possible. [...] There is no way in which we can look at the world and then at a sentence and ask whether they fit. There is just the expression (of the world) in speech (or thought) (Bhaskar, 1978:249).

Bhaskar thus rejects a narrow correspondence theory in which statements must directly mirror the world in order to be true. Because propositions and states of affairs are ontologically heterogeneous, the truth of a proposition cannot be established through simple comparison.

In his later work, Bhaskar (2008) develops the concept of *alethic truth*. Whereas in *A Realist Theory of Science* truth is discussed largely from the standpoint of scientists posing "questions to nature [...] in a language that nature understands" (Bhaskar, 1978:54), alethic truth reverses this orientation. As Hartwig (2007c:26) explains: "Humans do not bring truth to the world [...]; rather the world imposes its truth on us." Truth is therefore not merely an epistemological property of propositions but an ontological feature of being. The truth of the claim "in this moment, you are reading words in English" resides in the practice of reading itself, independently of the claim about it.

Human beings, including scientists, formulate propositions to express aspects of the world, and some of these propositions are conventionally regarded as true. Yet, because we can never step outside the limits of our human standpoint (Nagel, 1974), no ultimate warrant can guarantee their truth. As Bhaskar (2008:14) suggests, "we can know something, but not how much." Fallibility is therefore not an accidental weakness of knowledge but a constitutive feature of it.

Alethic truth can thus be understood as an "epistemologically mediated ontology"—an "ontology given the possibility of language [and] human practice" (Bhaskar in Bhaskar and Hartwig, 2010:130). Knowledge is always limited, provisional, and revisable, even when it successfully refers to real causal structures. This is a foundational orientation for critical realism.

The central implication is not primarily an intricate theory of truth, but the recognition that epistemology and ontology are inseparable yet irreducible to one another. Epistemology cannot be articulated without ontological presuppositions, and reality can only be accessed through epistemological mediation. As Graeber (2015:24) aptly puts it, it may be most appropriate to "define 'reality' as precisely that which we can never know completely." If knowledge and reality were identical, the very possibility of error, learning, and correction—and thus also uncertainty, as discussed in Chapter 2—would disappear. The intransitive independence of reality is therefore a precondition for knowledge.

Bhaskar (1978:249) captures this relation succinctly: "[e]pistemological relativism [...] is the handmaiden of ontological realism" (Bhaskar, 1978:249). Elsewhere, he describes it as the "*duality of truth*" (Bhaskar, 1986:99, his emphasis) or the "dialectic of truth" (Bhaskar, 2008:200). One of the major errors of modern philosophy, in his view, lies in collapsing this duality—either through the *epistemic fallacy*, which reduces being to knowledge, or the *ontic fallacy*, which reduces knowledge to being (Bhaskar, 1978:36–37, 1986:100, 2008:373–374).

It is crucial to emphasize that the distinction between world and knowledge is not a distinction between reality and non-reality. Rather, it is a distinction between what exists independently of human activity and what depends upon it. Mind-dependent entities such as beliefs, theories, and concepts are themselves real, but they "have a reality not to be confused with the reality of [their] objects" (Bhaskar, 1978:250). In this sense, epistemology is contained within ontology: ontology encompasses epistemology, but is not exhausted by it. Figure 1 (p. 34) schematically illustrates this relationship.

Finally, this reasoning applies not only to scientific inquiry but also to everyday life. We constantly rely on implicit assumptions about the causal powers of the world. When I get out of bed, I trust the floor's power to support me and gravity's power to keep me grounded. When I press the "T" key on my keyboard, I expect it to produce a "T" on the screen. When I purchase a train ticket, I expect the conductor to recognise it as valid. Such practices presuppose fallible yet practically reliable explanatory knowledge.

Explanatory knowledge can therefore be understood as a set of propositions about causal powers that are assumed to be true, though never guaranteed. I cannot be certain that gravity will still apply tomorrow, that my keyboard will work, or that my train ticket will not malfunction. These everyday examples also underscore that causal powers are not confined to biophysical nature alone but extend to social reality.

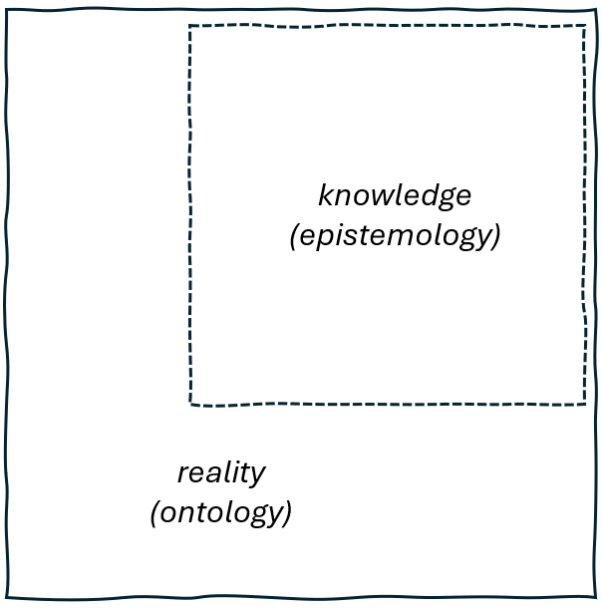

Figure 1: Schematic representation of the relationship between reality and knowledge (or ontology and epistemology as theories of reality and knowledge) (Source: Author).

3.2 Society, the individual, and normative action in critical realism

This section presents the outlines of a critical realist account of society. I begin by sketching the causal powers at work in society (Section 3.2.1), before turning to an account of individual subjects within it (Section 3.2.2). Building on these insights, Section 3.2.3 develops a third key pillar of CR: judgemental rationality, which complements the central contours of critical realist metatheory.

3.2.1 Agency and structure: Causality in the social world

Having so far focused primarily on the natural dimensions of reality and the forms of knowledge associated with them, an obvious question arises: how can anthropogenic elements be conceptualised within the framework of CR outlined above? This question is addressed most explicitly in Bhaskar's second major work, *The Possibility of Naturalism* (Bhaskar, 1998), which has exerted considerable influence within the social sciences and has been further developed by scholars such as Margaret Archer (1995, 2000, 2003), Andrew Sayer (1992, 2000), and Dave Elder-Vass (2010, 2012).

A common starting point for approaching causality in the social world is the basic social entity that embodies causal powers: the human subject. In the social sciences, *human agency* is typically understood as the capacity of individuals to act intentionally—to do what they intend and desire. This notion is often contrasted with that of *social structure*, which refers to the forces that shape, enable, or constrain individual action. CR seeks to reconcile these perspectives by conceptualising both agency and social structures as forms of causal power. Individual actions, in this sense, can be understood as the social analogue of events in the natural world: they result from the interplay of multiple causal powers rooted in individuals' intentions, their corporeal materiality, and their social embedding.

Viewed from the opposite perspective, the very possibility of human action presupposes that the world into which individuals are "thrown" is not fully predetermined. As Hartwig (2007f:103) observes, "human intentional agency, as the power to bring about a state of affairs that would not otherwise have obtained, presupposes the openness of the world." Yet this openness is not unlimited. It is constrained by causal powers external to the individual. Accordingly, the causal powers possessed by individuals must be distinguished from those that act upon them—powers over which individuals have no direct control (Bhaskar, 1998:90). Human beings are therefore not only sources of causal power, but also subjects to it.

While biophysical powers—such as those associated with illness or ageing—clearly affect individuals, there also exist social causal powers that act upon them. Classical social theory often conceptualises these powers under the general rubric of *power*, as in the notion of "power

relations," where human agency is restricted, shaped, or exploited—whether through economic relations, as in Marxist theory, or through discourse and knowledge, as in Foucault's work. Bhaskar refers to this specific form of social causality as *power*$_2$, distinguishing it from the more general sense of causal power (*power*$_1$) found in nature and individual agency (Bhaskar, 2008:55; Bhaskar and Hartwig, 2016:55). Power$_2$ thus refers to social structures and relations that exert causal influence over agents (Elder-Vass, 2010; Sayer, 2012). For the sake of clarity, and to avoid unnecessary terminological complexity, I use *power* here in the general sense of causal power and refer explicitly to *social structures* when discussing socially mediated forms of constraint or enablement.

CR explicitly positions itself against both atomistic and holistic conceptions of society. On the one hand, Weberian individualism treats social structures as mere aggregates of individual actions; on the other, Durkheimian holism views individual behaviour as determined by social structures. Both positions are regarded as reductionist: the former reduces society to individual agency, while the latter reduces agency to structural effects (Bhaskar, 1998:ch. 2). Instead, CR conceives of individuals and society as standing in a dialectical relationship, echoing Marx's well-known formulation that people "make their own history, but not of their own free will; not under circumstances they themselves have chosen but under the given and inherited circumstances with which they are directly confronted" (quoted in Bhaskar, 1986:136).

From this perspective, any human action is conditioned by an individual's position within a pre-existing social matrix (Bhaskar, 1986:118–135). This structuring matrix can be conceptualised in different ways: as stable patterns of behaviour, as law-like regularities governing individual conduct, or as systems of rules, resources, and relations among social actors (Porpora, 1989)[12]. While the first conception is individualist and the second sociologically holist, CR adopts the third. It therefore places particular emphasis on the relational character of social structures: social structures emerge from relations between individuals but are irreducible to them (Elder-Vass, 2010). At the same time, these structures constitute necessary conditions for action, while human agency, in turn, reproduces or transforms them. Society thus both enables and constrains agency, while depending on agency for its continued existence.

This understanding is formalised in Bhaskar's Transformational Model of Social Activity (Bhaskar, 1998:ch. 2), which foregrounds the temporal dimension of the structure-agency relationship (Archer, 1995). While social structures predate individual actions, human beings are "logically and ontologically prior to the social being," insofar as social properties and powers are ultimately

[12] Porpora (1989) further differentiates the latter conception of social structure into, on the one hand, a more idealist understanding of organising principles (often associated with Giddens, 1986) and, on the other hand, a more Marxist orientation that emphasises material relations between social positions. For the sake of simplicity—and in light of the discussion of the relationship between intransitive material reality and transitive knowledge in Section 3.1—I set aside a more fine-grained analysis of the differences between these two conceptions of social structure.

grounded in human ones (Archer, 2000:190). Individuals are always "thrown" into pre-existing social contexts that condition their actions, yet these contexts persist only through the ongoing activities of agents. Importantly, conditioning should not be confused with determinism:

> Since to condition entails the existence of something that is conditioned, and because conditioning is not determinism, then this process necessarily involves the interplay between two different kinds of causal powers—those pertaining to structures and those belonging to agents. Therefore, an adequate conceptualisation of conditioning must deal with the interplay between these two powers. Firstly, this involves a specification of *how* structural and cultural powers impinge upon agents, and secondly of *how* agents use their own personal powers to act 'so rather than otherwise', in such situations (Archer, 2003:3, her emphasis).

Although this dialectical account bears some resemblance to Giddens' (1986) structuration theory, CR explicitly diverges from it. While Giddens conceptualises structure and agency as inseparable moments of social action, CR insists that they are ontologically distinct and analytically separable. This distinction—termed *analytical dualism*—is crucial for analysing causal dynamics in social life, that is, for explaining how and why social systems reproduce themselves or undergo change (Archer, 1995; see also Section 4.1.1 on dialectics and dualisms). Structure and agency operate on different temporal planes and remain only relatively stable, continually subject to diachronic transformation.

The critical realist resolution of the structure–agency problem is thus grounded in a broader understanding of causality as the interplay of multiple, irreducible causal powers, as discussed earlier with regard to natural causation. At the same time, as Porpora (2022:6) aptly notes, "the causal logic of speech acts is different from that of electromagnetic charge or molecular bonding." Bhaskar (1986:122) therefore proposes a key criterion for distinguishing social from natural causes: social causes, while pre-existing and conditioning action, persist only through human agency. In other words, causes in the social world—whether structures or agency—"do not exist independently of the activities they govern" or of the meanings agents attribute to them (Bhaskar, 1998:42). Human practices and the structures they reproduce are thus intrinsically meaning-dependent, which fundamentally distinguishes social causality from natural causality.[13]

[13] Philosopher Ian Hacking (1999), notably without direct reference to Bhaskar, offers a strikingly similar analytical distinction between the natural and social sciences through his concept of "interactive kinds." In the social sciences, Hacking argues, classifications can interact with the very subjects they aim to describe, thereby generating feedback loops that shape behaviour and identity. The category of "woman refugee," for example, exemplifies an interactive kind: individuals who are so classified may become aware of the label and modify their behaviour in response. By contrast, natural entities such as quarks constitute "non-interactive kinds," since their classification does not influence their behaviour; they are not conscious entities capable of self-reflection or response. As Hacking (1999:32) succinctly puts it, "The classifications of the social sciences are interactive. The classifications and concepts of the natural sciences are not." In this respect, Hacking's argument also challenges radical social constructivist interpretations of natural scientific knowledge—an implication that closely aligns with, though is not explicitly grounded in, CR.

In conclusion, the human subject is a cause among many, whose actions presuppose both a material world and a social context that predate individual cognition. Social events are shaped not only by biophysical laws but also by social structures and individual agency (Elder-Vass, 2010). Because human agency and social structures are concept- and meaning-dependent, understanding society requires deeper attention to the reflective, meaning-making capacity of human beings.

3.2.2 Mind, meaning, and action

The capacity of human subjects to act in the world—and the underlying reason they are able to do so—emerges from a multiplicity of strata or levels that constitute human beings. A more detailed account of these levels can be found in Bhaskar (2008:139), but for the purposes of this discussion they can be simplified into three interrelated layers: the biological, the unconscious, and the self-conscious. In line with the principle of emergence, each higher level depends on—but is not reducible to—the levels beneath it. Thus, a (self-)conscious person necessarily possesses specific biological (e.g. genetic, neurological) capacities and unconscious (e.g. Freudian) drives. Yet self-consciousness, or mind, also exhibits emergent properties that are not predetermined by these lower strata.

This perspective stands in opposition to both dualist and reductionist theories of mind. Dualism posits a separation between a spiritual mind and the biological brain, while reductionism seeks to collapse mind into purely neurophysiological—or material—processes. CR transcends this dichotomy through its notion of emergence: consciousness arises from the material substrate of the brain but cannot be reduced to it (Bhaskar, 1998:106–111; see also Sayer, 2019, for a related argument on normativity). This position is consistent with evolutionary biology, which likewise understands mind as emerging from matter. At the same time, atomistic or behaviourist models that treat the individual as an isolated mind–body unit abstracted from social and natural contexts are inadequate (Bhaskar, 1998:115). A mindful, subjective self must therefore be understood as grounded in both corporeal materiality and social embeddedness, and cannot be conceived in abstraction from these conditions.

In this respect, CR partially converges with postmodern critiques of a unified and stable self, which emphasise the fluidity of subjectivity and its shaping through discursive and material contexts. The self is thus not fixed, but susceptible to transformation through interaction with its surroundings—evident both in inter-individual differences and in intra-individual change over time. However, as Hartwig (2007i:443) provocatively asks, “If we reject such [unified] notions of the self, who is it that announces the rejection?” This question exposes a tension in postmodern thought: even the critique of unity presupposes a subject capable of articulating that critique.

CR addresses this tension by analytically distinguishing between intrinsic and extrinsic aspects of mind (Bhaskar, 1986:16–17). The intrinsic aspect concerns intentionality, reflexivity, and other

mental features, while the extrinsic aspect refers to historically and contextually conditioned characteristics. From the perspective of individual cognition, the intrinsic includes normative commitments and self-reflection, whereas the extrinsic encompasses knowledge of the socio-material context and the ways in which individuals respond causally to it.

Despite this analytical distinction, neither aspect can be understood in isolation. Both are "features of the apprehending consciousness itself, and, as such, real" (Bhaskar, 1986:17). Neither should therefore be reduced to the other—as in objectivist positivism, which reduces cognition to external stimuli, or existential idealism, which collapses external reality into inner thought (Bhaskar, 1986:16–18). Praxis, understood as transformative engagement with the world, necessarily presupposes both an account of that world and reasons for intervention. Accordingly, the extrinsic aspect of mind is both logically and temporally prior to the intrinsic (Bhaskar, 1998:89–90; see also Archer, 2003): without a world, there could be no consciousness of it, and thus no transformative action.

At the same time, individuals are always already "thrown" into a world they did not choose; contextual embeddedness is inescapable. As Norrie (2010:74) puts it, "the things people think and the reasons why they act in a material, spatio-temporal world are the product of thinking *in that world*, not just of thinking per se, so that determinacy in thought or action is the product of the contextualised 'thrownness' of thinking in a geo-historic context". Thinking, in this sense, becomes a form of praxis that informs and shapes material action. Praxis therefore involves a relational movement: a self relating to a contextual "else."[14] This relationality is possible because human beings are, ontologically speaking, made of the same "stuff" as the world itself—they are part of it, and both are real.

Like the world, the mind exhibits depth. No one can fully comprehend another person from the outside; nor can individuals achieve complete self-transparency. Our understanding of the world is always limited and fallible (Hannah, 1999), and the same holds for our understanding of ourselves.

In this way, this section has outlined some foundational principles for understanding how human subjects cognitively engage with and act within the world. What remains underexplored so far is the dimension of normativity—the striving for the good. This will be the focus of the next section.

3.2.3 Judgemental rationality and normative practice

As established above, the world pre-exists individual human activity and is knowable only in relation to human minds and the historical-social conditions in which individuals are embedded. Yet

[14] This thought will be further explored in the discussion of referential detachment in Section 4.1.3.

world and knowledge alone do not suffice to explain action; action also requires a normative orientation—a reason, value, or moral intention that motivates intervention.

To account for this dimension, it is important to recall that all human knowledge and practice necessarily involve theoretical antecedents. Theory, in turn, is informed by material interventions in the world: we learn from what we do, just as scientists learn through experimentation (see Section 3.2.2). This reciprocal relationship establishes a duality of theory and practice that allows for reflexivity. Theory presupposes practice and is therefore quasi-practical, while practice presupposes theory and is quasi-propositional—every human action implicitly makes claims about the world. As Bhaskar (2008:60) notes, theoretical reasoning is "concerned to adjust our beliefs to the world," whereas practical reasoning seeks "to adjust the world to our will." Through this mutual dependency, theory-practice complexes evolve: practice prompts theoretical reflection, which informs new practice, in a recursive, dialectical spiral (Bhaskar, 1986:173). This helix lies at the core of transformative agency and underpins the structure-agency relationship.

This duality also informs CR's approach to normativity and morality. CR adopts a form of moral realism or ethical naturalism, according to which moral properties exist independently of individual perception or mediation—there is something in the world that is good. At the same time, as with all knowledge in CR, moral understanding is context-dependent. Normative judgements are therefore always made by concrete human subjects situated within specific socio-historical conditions:

> The extent and ways in which normative considerations may become causally efficacious (and so real) in the generative matrix in which human action occurs cannot be settled by philosophical fiat in abstraction from consideration of specific cases (Bhaskar, 1986:17).

Accordingly, CR rejects the notion of known, absolute, or universally applicable ethical norms.

CR also challenges the classical is-ought or fact-value dichotomy, famously articulated by David Hume, according to which normative claims ("ought") cannot be derived from descriptive claims ("is"). Bhaskar contests this separation by arguing that asserting a fact already implies a normative preference for truth over falsehood. As he puts it, the statement "'X is true' entails 'act on X (in appropriate circumstances) CP [ceteris paribus]'" (Bhaskar, 1986:183). Or, as Hartwig (2007g:160) succinctly formulates it, "saying how the world is is to offer implicit advice to act on that information."

Normative judgements about right and wrong are thus always made in relation to truths that themselves refer to a reality transcending any particular description. Values do not exist outside reason; rather, they emerge from reasoned engagement with a contextually situated but transcendent reality (Sayer, 2011). Desires, norms, and values are therefore neither arbitrary nor purely subjective, but arise through reflective practice. At the same time, value judgements imply commitments to action.

Accordingly, statements about normativity can only be made within, or by reference to, truths that point beyond themselves to an independent reality. Values are not external to reason (Sayer, 2011), but emerge through reasoned knowledge-making of a contextual yet transcending reality.[15] Desires, norms, and values—and ultimately practices—thus arise in relation to the world. Agency, in this normative sense, "presupposes a world, which has occurred and will come again to pass, without [humans]" (Bhaskar, 2008:214).

Still, normative action is not exhausted by its context. It also entails "meta-epistemic reflexivity and ethical (moral, social and political) responsibility on the part of the cognitive agents concerned" (Bhaskar, 1986:24–25). Reflexivity, as understood by Archer (2003) as an internal conversation with oneself, refers to the subject's capacity to locate and evaluate their own position and potential actions within a broader field of causal powers. In this sense, reflexivity functions as the "real mediatory mechanism" between structure and agency (Archer, 2019:251), enabling "just such things as articulating to ourselves, where we are placed, ascertaining where our interests lie and adumbrating schemes of future action" (Archer, 2003:9).

As emergent beings embedded in a real world, human subjects thus possess the capacity to reason, choose between alternatives, and evaluate actions: "Normativity [...] is intrinsic to human being" (Sayer, 2011:246). Human beings are always judging and evaluating the world they know—and thereby the world itself (Sayer, 2019). This forms the basis of what CR terms *judgemental rationality*, and the position that underpins it is known as *judgemental rationalism*.

This conception of rationality differs both from classical philosophical rationalism, which treats reason as the supreme source of knowledge, and from rational choice theory in neoclassical economics. Judgemental rationality makes no claim to universality: judgements are always made within, and against, particular contexts (Norrie, 2010). Reason and values are not opposed but co-constitutive; values fall "within the scope of reason" (Sayer, 2011:11).

Judgemental rationality therefore holds that normative and practical evaluations are both necessary and possible. Given epistemic relativism about a shared, stratified real world (ontological realism), not all perspectives are equally valid. Some claims are better justified than others, and there are good reasons for making normative distinctions. Yet the criteria for such judgements cannot be fixed in advance; they must remain contextual, situated, and fallible. Moreover, given the dialectic between structure and agency and the multiplicity of causal powers operating in

[15] Applied to the fact-value dichotomy often advocated in philosophy and science, this implies that the notion of a "value-free science" is as untenable as that of "science-free values" (Hartwig, 2007e:95–96). It is not only the case that facts are value-laden, but also that "*values are fact laden*" (Gorski, 2013:543, his emphasis; see also Bhaskar, 1998:60).

society, norms conditioning individual judgement are socially provided, while individuals nonetheless retain the capacity to conform to—or deviate from—those norms (Elder-Vass, 2010:ch. 6).[16]

From a critical realist perspective, ethical judgement thus presupposes epistemology, which in turn presupposes ontology. In CR terms: judgemental rationality arises within (but does not exhaust) epistemic relativism, which itself arises within (but does not exhaust) ontological realism. Conversely, ontological realism makes epistemic relativism possible, which in turn makes judgemental rationality possible (Bhaskar, 1986:24–25). Together, these three principles form what Bhaskar and Hartwig (2016:6) call the "holy trinity" of CR.[17] The diagram presented in Section 3.1.3 can therefore be expanded to include an additional dimension: normativity and ethics (see Figure 2, p. 43).

Crucially, human beings are always situated within all three dimensions. One cannot apprehend the world in a purely objective (outside epistemology) or neutral (outside normativity) manner. Every subject is always already in the world, knowing the world, and judging the world.[18] These dimensions converge in praxis, as human beings are "always already acting" (Bhaskar, 1986:188). Even inaction constitutes a form of action.

This existential necessity of acting is described in CR as the *axiological imperative*. It holds that intention and action are mutually entailed: "For what I will do will happen not in spite, but because, of any decisions, etc., I take (and more generally, the beliefs and purposes I have)" (Bhaskar, 1998:96). Reasons—emerging through judgement and situated knowledge—therefore "can and must be causes for any theoretical or practical activity to be possible" (Bhaskar, 1998:175). Ultimately, it is reason, embedded in and mediated by a multiplicity of causal powers in the world, that functions as a core causal power in the actualisation of human practice.

[16] Deviating from a socially shared norm may entail social consequences, as illustrated by Elder-Vass's (2010:126) example of a person stealing a loaf of bread to feed their hungry children. The case highlights the multiplicity of causal powers acting on individuals, such as corporeal need and parental care, which may override both social norms and the anticipation of sanctions.

[17] The notion of "holy" is an intentional pun on "holes," referring to absences in the dialectical sense (Bhaskar, 2008:39; see also Section 4.1.2). In his later, more spiritual work, Bhaskar (2012b:277) speaks of a "trialectic of being, agency, and perception," where perception is understood in a much broader and more encompassing sense than discussed in section 2.3. All three modes of this trialectic are reciprocally connected—when one mode changes, the others change as well.

[18] For a comparable dialectical-relational account outside CR, see Rosa (2020), especially pp. 62-63.

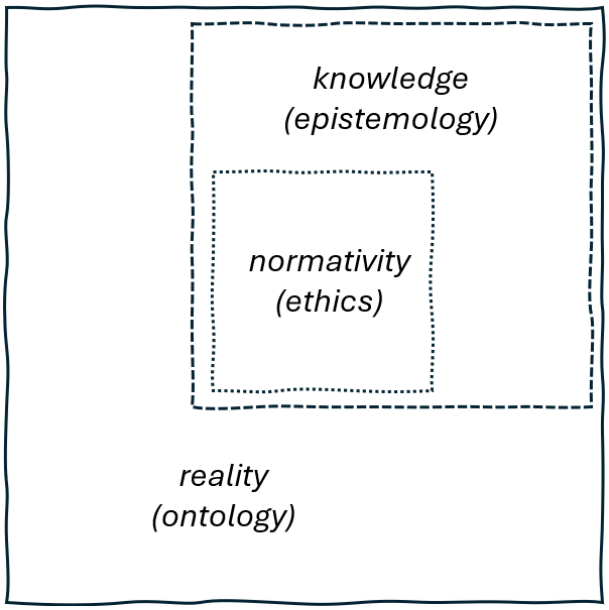

Figure 2: Schematic representation of the relationship between being, knowledge, and normativity (i.e., ontology, epistemology, and ethics as theories of being, knowledge, and normativity), inspired by Diagram 1.1 in Bhaskar (1986:25) (Source: Author).

3.3 Why perception is not enough: Towards a critical realist approach to knowledge and praxis

In light of the theoretical discussions on causality, knowledge, and practice in Sections 3.1 and 3.2, the core issue in FACC, as outlined in Chapter 2, becomes clearer: the need to think in terms of complex socio-ecological systems and to confront the corresponding paradox of uncertainty. The paradigm of complex adaptive systems calls for abandoning deterministic views of biophysical nature and one-size-fits-all solutions in forest management. Instead, it emphasises diversity, resilience, and reflexivity. Its defining feature—uncertainty—gives rise to a paradox: while human practice desires predictive knowledge of a stable world, that world must remain open in order to permit intervention, thereby contradicting the very idea of full predictability.

The theoretical foundations developed thus far serve both as underlabourer and as a pathway for rethinking these issues. First, the notion of ontological depth and open systems clearly applies to FACC. Forest ecosystems encompass a multiplicity of causal powers, ranging from large-scale physical and climatic conditions to biological processes operating within organisms across genetic, morphological, intra- and interspecific levels. Crucially, these powers and their interactions are not directly observable. Because forests are open systems that cannot be controlled under laboratory conditions, isolating individual causal mechanisms—let alone identifying all of them—is exceedingly difficult. Even if such isolation were theoretically possible, the long temporal horizons of tree growth would render experimentation impractical. Past experience provides only partial guidance, as there is no guarantee that theories derived from historical conditions will remain valid under future climatic scenarios.

Second, the causal powers of anthropogenic society introduce an additional layer of complexity. Individuals act not only on the basis of their knowledge of biophysical systems but also according to their—equally limited—understanding of the social systems in which they are embedded. These systems precede human action, shaping and enabling it, yet they also depend on continued human activity for their reproduction. Within this dual context of biophysical and social forces—and under conditions of limited knowledge—individuals must make normative judgements about what ought to be done. These dimensions culminate in the axiological imperative to act, which is ever present in FACC, particularly when one recognises that even the absence of adaptive practice constitutes a management option (see Section 2.2).

Third, this axiological imperative—together with the embedding of judgement and practice within knowledge and the world (or normativity within epistemology within ontology)—helps explain why the paradox of uncertainty assumes particular importance in FACC. Actors inevitably approach the world as already acting, judging, and knowing beings; they can never grasp it "as it is." Yet the world undeniably exists, and actors are thrown into it—thus always already part of and related to it. For this reason, an empirical exploration of uncertainty may best begin not from "the world as such," but from the requirements to know and act within it, since human–world relations are already contained within these requirements.

These considerations underline the shortcomings of studying "perception" as the primary empirical lens for investigating FACC (see Section 2.3). Such approaches implicitly presuppose a world that is flat, repetitive, and largely unchanging. Perception is treated as a fixed object or event exhibiting relatively uniform patterns across actors, with this presumed uniformity then causally linked to other events—such as management practices or contextual variables (e.g., institutional embedding, economic conditions, gender). The fundamental problem is therefore that such approaches operate almost exclusively at the level of the actual.

This actualistic and mechanistic conception is reflected in the empiricist—often positivist—methodologies employed in the studies discussed in Section 2.3. Only what can be empirically captured about perception is assumed to represent what is truly occurring in people's minds, while causal relations are inferred through constant conjunctions of events, typically in quantitative form (even when based on qualitative data such as interview transcripts analysed through content analysis).

Viewed through a critical realist lens, it becomes clear why these conceptual and methodological approaches fall short of addressing the core challenges posed by complex adaptive systems and the paradox of uncertainty.

First, focusing on isolated events—such as responses to standardised questions or "perceptions" more broadly—fails to capture the causal depth and contextual complexity of knowledge and practice. This complexity arises from a multiplicity of interacting causal powers that are not

immediately visible at the surface level. The reasons behind specific actions are therefore too multilayered and contextually embedded to be adequately grasped through descriptions of "subjective" perceptions of an "external" world—particularly when such descriptions are implicitly contrasted with natural scientific knowledge as the presumed bearer of final or superior truth.

Second, the notion of perception commits what Bhaskar terms the *epistemic fallacy*—the conflation of epistemology with ontology. By reducing the world to what is perceived or known, it ignores, on the one hand, the existence of causal powers in biophysical nature that exceed human epistemic access. Indeed, the pervasive uncertainty characterising FACC itself indicates this ontological transcendence: causal mechanisms are at work that cannot be fully captured epistemically. On the other hand, this approach also neglects causal powers within the anthropogenic world—such as human agency and social structures—or reduces them to transitive moments of consciousness detached from material reality.

Third, perception-based approaches fail to address the elements of time, change, and openness that are central to FACC. By concentrating only on what currently exists or is known, both the world and knowledge are implicitly assumed to be stable and homogeneous. Everything collapses into a single temporal moment, leaving no space for alternative futures. Consequently, such studies risk becoming counterfactual in their implications: their findings provide little basis for normative or critical movement forward, as they remain confined to an actualist present.

Fourth, whether perception or knowledge is conceived in positivist or constructivist terms ultimately makes little difference—both positions share the problematic assumption that what matters is limited to what is known or perceived.[19] Both thereby deny the ontological depth of reality and hinder explanatory inquiry (Sayer, 1992; Bhaskar, 1998:ch.4; Danermark et al., 2002). If knowledge is assumed to directly represent reality, as in positivism, studying knowledge becomes redundant—the object alone would suffice. Conversely, if knowledge is voluntaristically understood as whatever exists within socially shaped minds, explanation becomes equally futile, as each instance would be unique and incomparable.

A similar difficulty extends to methodological attempts to grasp "perception." If behaviour is to be explained at the micro-level of individuals, quantitative surveys are ill-suited, as they reduce agency to predefined variables. If the focus instead shifts to causal powers beyond individual agency—such as the social and, in the case of FACC, especially biophysical structures that actors confront—it becomes equally questionable how the depth of such structures can be captured through superficial data such as questionnaire responses alone. What is needed, therefore, is an approach capable of analysing the emergence of practice from a multiplicity of causal powers.

[19] For Bhaskar (1998:138), constructivism is "the anti-scientific romantic reaction which has always coexisted in symbiosis" with positivism.

In this light, it appears more fruitful to move beyond the narrow notion of perception and instead focus on the relations between humans and nature as articulated through knowledge and practice—particularly if knowledge itself is understood as a form of practice. Knowledge and practice are thus not isolated events detached from the biophysical world but relational processes: dynamic interactions between socially embedded individuals and a reality that exceeds them, including both social and biophysical structures. The propositional nature of knowledge, as conceptualised in CR, aligns well with approaches that foreground uncertainty and similarly propositional forms of practice emphasised within complex adaptive systems theory, such as reflexive learning.

Such a perspective treats practice not as something requiring deterministic explanation—where "objective" or "subjective" factors produce predictable outcomes—but as one actualised event among many potential ones. In knowing and acting, individuals enter into relations with the causal powers of the world. This view therefore re-emphasises what is "other" or "more" in reality—elements not immediately available to a perceiving mind.[20] This "radical alterity" of the world (Graeber, 2015) is not only a precondition for uncertainty but also for understanding human–nature relations, as it establishes the necessary distinction between knowledge and the world.

Accordingly, in light of this discussion and the broader research interest outlined in Section 1.2, it is useful to refine the terminology introduced in Section 2.4. I employ *uncertainty* as an epistemological term referring to a state of knowledge about the world (i.e., a socio-ecological system), and *indeterminacy* as a broader ontological term referring to a state of the world itself—one that encompasses knowledge as well. Indeterminacy emerges from the dynamism of both the biophysical and social worlds and, in the case of FACC, from their entanglement. *Complexity*, in turn, denotes the multiplicity and reciprocity of causal powers shaping human–nature relations, including biophysical mechanisms, human knowledge, and agency as actualised in practice, all of which both shape and are shaped by social structures.

Ultimately, however, such a relational approach raises the question of how this field of causal powers and relations can be analysed empirically. The perspective of the axiological moment offers a promising entry point, as it understands people as always already acting—and therefore judging, knowing, and relating to the world. Such moments unfold within a multicausal context comprising biophysical mechanisms, social structures, human agency, reasons, and values.

Yet because this complex interplay cannot be accessed directly at the empirical level, interpretation is required—that is, the mobilisation of a conceptual framework capable of abstracting

[20] In this sense, the epistemic fallacy is also committed by phenomenological and constructivist approaches to perception such as Ingold (2000). While his attempt to understand knowledge as part of being-in-the-world is compatible with CR, the claim that such processes exhaust the world would be rejected, as illustrated in Figure 1 (Section 3.1.3, p. 34).

toward the causal structures of the world (Sayer, 1992, 2000). In the next chapter, I therefore develop a framework aligned with the key issues of FACC identified in Chapter 2.

3.4 Conclusion: Toward a critical realist heuristic for FACC

In this chapter, I have introduced critical realism as a philosophical framework for understanding knowledge as well as social and individual practice—one that moves beyond the positivist and constructivist assumptions underlying perception-focused approaches. CR rests on three interrelated principles: *ontological realism,* which affirms the existence of a mind-independent and stratified reality; *epistemological relativism,* which recognises the fallibility, situatedness, and historicity of knowledge; and *judgemental rationality*, which sustains the possibility of reasoned evaluation and choice among competing knowledge claims.

Taken together, these principles demonstrate that practice always constitutes a relation to a world that is already known, interpreted, and morally mediated, while simultaneously exceeding such interpretations. Practice relies on the embodied causal powers of human beings, through which they are able to intervene in—and thereby contribute to the transformation of—the world.

A critical realist conception of causality is therefore central to an ontology of both the natural and the social that avoids the pitfalls of voluntarism and determinism alike. Understanding causality as potentiality allows difference, change, and uncertainty to be seen not as anomalies but as emergent features of reality. When the actual world is understood as the outcome of interacting causal powers, analytical attention necessarily shifts toward the relations through which these powers operate.

This perspective offers a productive way of approaching the challenges posed by FACC. The emphasis on complexity, change, and uncertainty suggests that ontological depth is at work in this field—depth that cannot be captured by studies confined to singular events of perception or to the determinate surface of practice. Instead, understanding FACC requires attention to the layered and interrelated causal mechanisms that shape both knowledge and action.

Such an endeavour depends on the development of an appropriate conceptual framework. The following chapter therefore advances a critical realist heuristic designed to engage more directly with the underlying dynamics of FACC and to provide analytical orientation for the empirical investigation that follows.

Chapter 4: Operationalising critical realism: A dialectical framework for analysing FACC

In the previous chapter, I showed why the two classical theoretical approaches—positivism and constructivism/poststructuralism[21]—are ultimately unable to provide a satisfactory response to the central challenges characterising the field of forest adaptation to climate change (FACC). I then introduced critical realism (CR) as an alternative metatheoretical framework grounded in three foundational principles: ontological realism, epistemological relativism, and judgemental rationality. Together, these principles offer a basis for engaging with the three interrelated challenges identified in Section 2.4: human–nature relations, change in socio-ecological systems, and the limitedness of knowledge and practice.

The task of the present chapter is to translate these philosophical commitments into a conceptual framework that can guide empirical analysis. I argue that this requires moving beyond "classical" critical realism toward Bhaskar's later development of dialectical critical realism (DCR). After establishing realist accounts of natural and social science in *A Realist Theory of Science* (Bhaskar, 1978) and *The Possibility of Naturalism* (Bhaskar, 1998), Bhaskar turned explicitly to the concept of dialectic in *Dialectic: The Pulse of Freedom* (Bhaskar, 2008; see also Bhaskar, 2010). Although this work is demanding and conceptually dense, its core contribution lies in articulating a mode of thinking oriented toward duality, absence, and change.

This dialectical orientation is particularly relevant for FACC, where change is not an exception but a defining condition. Bhaskar's dialectic can be understood as an attempt to "think about how being changes in time and space, and how philosophically that change is to be understood" (Norrie, 2010:15). In this sense, DCR reintroduces temporality and process into a framework that, at the level of metatheory, can otherwise appear abstract and static. It is precisely this grounding in time, place, and becoming that enables meaningful engagement with concrete empirical cases of FACC.

The chapter proceeds as follows. Section 4.1 introduces a set of key figures of DCR that are especially pertinent to FACC. Section 4.2 then uses these insights to reformulate the three central challenges of FACC in more differentiated terms and introduces the concept of the possible as a unifying analytical lens. Building on this, Section 4.3 develops a conceptual framework that operationalises these ideas for empirical analysis and situates the chosen terminology within relevant

[21] While the previous chapter primarily used the term *constructivism* as a counterpart to positivism—a distinction sometimes found in the FACC literature—I now mainly refer to *poststructuralism*. This shift reflects the central role that the concept of *structure* will play in the remainder of this thesis. Constructivism and poststructuralism are not identical, but they emerge from overlapping philosophical lineages and share important anti-foundational and anti-essentialist commitments. This broader intellectual constellation also includes related orientations such as postmodernism, posthumanism, and postdualism.

academic context. Finally, Section 4.4 concludes with a brief reflection on the contribution this framework can make to addressing both the practical and theoretical problems of FACC.

4.1 Thinking in constellational dialectics: Key figures of dialectical critical realism

This section introduces the key analytical figures that emerge from a dialectical elaboration of the three critical realist pillars outlined in the previous chapter—ontological realism, epistemological relativism, and judgemental rationality. I begin by showing how the seemingly contradictory concepts of duality and identity are sublated in Bhaskar's notion of a constellation (Section 4.1.1). This is then complemented by an account of absence and negation as a way of understanding change in the world (Section 4.1.2). Finally, Section 4.1.3 applies this dialectical perspective to human beings in relation to their context through the notions of reference and referential detachment. Taken together, these tools provide the conceptual equipment needed to rethink the challenges of FACC (see Section 4.2).

4.1.1 Duality and identity in constellational dialectics

In Chapter 3, I introduced a series of dualities such as agency–structure, fact–value, theory–practice, and—most importantly—the distinctions between knowledge and reality, and between the extrinsic and intrinsic aspects of human agency. I also argued that CR does not seek to dissolve these dualities or to think beyond them. Rather, it retains them in order to think *through* their relations.

This mode of reasoning—thinking relations through dualities—is characteristic of dialectics, whose modern philosophical origins are commonly traced to Hegel. In contemporary social theory, however, it has become fashionable to reject dualisms altogether, on the grounds that they impose a rigid either–or logic on the world. This critique rests on a mistaken conflation of *duality* with *dichotomy*. The existence of two distinct or even opposed elements does not preclude their interconnection or mutual implication. A dialectical mode of thought, by contrast, foregrounds relations, tensions, and processes between elements rather than their isolation (Ollman, 2003).

Drawing on Hegel, Marx, and the Frankfurt School, Bhaskar elaborates original or basic critical realism into *dialectical* critical realism by conceptualising opposites as *constellationally related*: one term is contained within the other without being reducible to it (see Bhaskar, 2008:372). Ontology, for example, overarches epistemology—epistemology emerges from and is contained within ontology, yet does not exhaust it. As illustrated in Figures 1 and 2 in Chapter 3 (p. 34 and p. 43), knowledge is part of reality but possesses causal powers distinct from, and irreducible to, the rest of reality. Reality is a necessary condition for knowledge, but not vice versa: reality could exist

without knowledge. A similar relation holds between theory and practice: theory emerges from practice and is itself a form of practice with emergent properties.

Accordingly, dualities such as agency–structure or theory–practice should not be understood as dichotomies but, in Bhaskar's (2008:319) formulation, as a "figure of identity-in-difference." Opposites are reciprocally connected and therefore constitute, in existential terms, a non-duality. They participate in an overarching identity, which ultimately corresponds to the notion of *totality*: the open, stratified system that constitutes the world.

Yet if totality were understood in a purely identitarian sense—if everything simply collapsed into sameness—analytical comprehension would become impossible. Bhaskar illustrates this problem through the distinction between existential intransitivity and discursive transitivity:

> When you are reading the newspaper, actually reading it, in that moment of reading it, it is not an object distinct from the reading, there is just the reading; existential intransitivity is lost. But then you cannot do what we call science (Bhaskar in Bhaskar and Hartwig, 2010:72).

For a relationship—such as that between reader and newspaper—to become analytically meaningful, it must be rendered dualistically: "for two things to interrelate causally, they must be ontologically distinct" (Porpora, 2015:159). Thinking a relation requires differentiated elements. Identity depends upon difference, and these differences are not reducible to one another.

Dialectics can therefore be understood as the art of thinking differentiated elements together while retaining their existential interdependence. To grasp totality is "to see things *existentially constituted*, and permeated, *by their relations with others*" (Bhaskar, 2008:115–116, his emphasis).

Totality, in this sense, is not a closed or fixed whole but a processual becoming. As Bhaskar (1986:209) notes, "the world is not just the totality of what is actually the case, but includes what might or could be, grounded in the structural properties of things." The defining characteristic of totality is therefore openness and unfinishedness.

Bhaskar's dialectics thus departs from Hegelian dialectics, which emphasised unilinearity, teleology, and final resolution (Sheppard, 2008; Norrie, 2010). Instead, dialectics becomes an ontology and heuristic of process, flux, and change.

Since the notion of change lies at the core of this thesis, dialectics provides a means to deepen the understanding of FACC by thinking "of causation in its processual aspect" (Norrie, 2010:216). Section 4.2 will draw on these insights to bring the three central challenges of FACC—human–nature relations, change, and limited knowledge—into dialogue with the conceptual tools developed here. Before doing so, the next sections introduce two additional figures that further specify how change can be conceptualised in socio-ecological contexts.

4.1.2 Negativity, absence, and becoming

Dialectic, in Bhaskar's sense, is not merely an epistemological mode of reasoning that operates within the transitive domain of knowledge. It is also an ontological principle: being itself is dialectical, insofar as temporal change and spatial differentiation arise from the dynamic interplay of causal powers. The concept that anchors this ontological dimension of dialectics is *absence*, or real negation.

Bhaskar (2008:172) characterises absence or negativity as "the missing metacategory par excellence" of Western philosophy. He argues that much of Western metaphysics either fails to conceptualise absence at all or subordinates it to presence. Against this tradition, Bhaskar establishes the necessity—and priority—of absence through transcendental reasoning:

> There could have been nothing rather than something. Of course this is a counterfactual. Beings exist. But by transcendental argument, non-being is constitutively essential to being. Non-being is a condition of possibility of being. No non-being is a sufficient condition of impossibility of being. But there is no logical incoherence in totally no being. [...] In sum, complete positivity is impossible, but sheer indeterminate negativity is not (Bhaskar, 2008:43).

Philosophical frameworks that lack this prioritised concept of absence are described by Bhaskar as subscribing to *ontological monovalence*: a "purely positive account of reality" (Bhaskar, 2008:377). Ontological monovalence eliminates the domain of the real and culminates in actualism, where "[a]ll that there is is there, so that 'what you see is what you get', that and no more" (Norrie, 2010:177), and where "the non-actual real" is erased (Bhaskar, 2010:42). The consequence is not only a "dogmatically reinforced positivization of knowledge" but also an "eternalization of the status quo" (Bhaskar, 2008:377). If absence is denied, the ontological possibility of alternatives is foreclosed. A purely actualist world, in this sense, cannot accommodate genuine change.

Absence is therefore foundational to dialectics because it is a necessary condition for change.[22] While absence may refer to a specific state of affairs—something not present at a given time and place—it also underpins process itself. Change is fundamentally characterised by "the absenting of absences, as well as the absenting of those structural constraints that keep absences in place" (Norrie, 2010:28). Novelty does not emerge ex nihilo. Rather, new forms arise through the

[22] One might ask why absence and negativity appear to possess ontological priority over presence. One reason is that the negative cannot be fully translated into a positive without loss of meaning. As Bhaskar (2008:6) notes: "Pierre's absence from the café doesn't mean the same as his presence at home (although the latter entails the former—which is equally entailed by his death) any more than it means the same as Jean's occupying his customary place." A positive statement can delimit a specific absence, but a negative statement does not uniquely specify a corresponding presence.

sublation of prior constraints.[23] The new is thus never radically disconnected from the old; it emerges through and in relation to existing structures.

Absence is not only a condition for ontological change and the openness of totality, but also for knowledge. On the one hand, knowledge is fallible and therefore necessarily incomplete: errors, gaps, and misconceptions are themselves absences that may be progressively absented through critique and inquiry. On the other hand, absence within being is a prerequisite for intelligibility as such: "a sentence without absences, pauses or spaces, would be unintelligible" (Bhaskar, 2008:224). What is not present is therefore a condition for the existence and recognisability of what is present.

Ultimately, absence is also central to praxis and normativity. Human agents possess the causal power—activated through embodied intentionality and expressed in reasons as causes—to bring about events in the world. To act is, at the same time, to prevent other possible events from occurring. Concrete practice is therefore always a form of selective absenting. As Bhaskar (2008:185) notes: "Human agency must be understood as embodied intentional causal absenting."

Normative orientation within praxis is consequently directed toward what is not yet the case. Desires, values, and goals express experienced absences, and action aims at removing the constraints that sustain them. Dialectic, in this practical sense, becomes "the absenting of constraints on the absenting of absences" (Bhaskar, 2008:352). Absence thus appears not as lack or deficiency, but as the generative condition of agency, critique, and emancipation.

Dialectic, in Bhaskar's account, is therefore irreducibly three-dimensional: ontological, epistemological, and normative–practical (Bhaskar, 2008:3; Norrie, 2010:27–28). With the concept of absence, another foundational element for thinking process, change, and openness has been established. The next section shifts focus from this general ontology of becoming to the situated human subject, through the notions of reference and referential detachment.

4.1.3 Referential detachment

As emphasised throughout this thesis, individual human beings are part of the world, yet can never fully comprehend it. At the same time, they are always already thrown into this constantly changing reality, "as if into an already moving vehicle" (Bhaskar, 2008:83–84). Human beings are therefore compelled to live and act within, and in relation to, a world that precedes them and exceeds their understanding. Much of this world remains radically other to the individual self (Graeber, 2015) and can never be fully appropriated. No matter how much I care for a pet or love another

[23] The term *sublation* (verb: *sublate*) translates Hegel's concept of *Aufhebung*, which carries a threefold meaning in German: to "cancel, preserve, and transcend" (Bhaskar, 2008:381). Bhaskar adopts this term to emphasise that change simultaneously negates prior forms, retains aspects of them, and moves beyond them. Where the term appears in the main text, its intended sense is indicated in brackets.

person, I can never feel as they feel; I can never fully grasp the original intent of a book or all the expectations of my PhD supervisor; I can never be entirely certain that a tree I plant will encounter all the conditions it needs to grow.

From the standpoint of the individual, the world thus appears as fundamentally different from the self. Nevertheless, human beings are constantly engaged in acts of relating to and referring beyond themselves. This "need to refer to something other than ourselves" (Bhaskar, 2008:37) constitutes a fundamental human condition. Like the need to act (see Section 3.2.3), it forms part of what Bhaskar terms the *axiological imperative*: every human act is necessarily oriented toward something external to the acting subject.

To analyse this orientation, Bhaskar introduces a crucial distinction between the act of referring and the *referent*—that which is referred to. These two are not only analytically separable but *detached* (Bhaskar, 2008:37). For example, the statement "There is a tree in the forest" is not the same as the tree itself, although it refers to it. Likewise, the practical act of felling a tree is materially different from the tree's mere existence, even though the latter is a precondition for the former. Referential activity, whether discursive or practical, therefore does not collapse into its referent.

This notion of *referential detachment* is central to Bhaskar's philosophy because it provides an argumentative bridge between several of the key tenets developed thus far. As Bhaskar explains:

> The argument for *ontology* is just the argument for *existential intransitivity*, which is just the argument for *referential detachment*. Realism in the sense that involves existential intransitivity is a presupposition of *discourse* which must be *about* something other than itself, of *praxis* which must be *with* something other than itself or of *desire* which must be *for* something alterior to itself (Bhaskar, 2008:198, his emphasis).

This passage highlights Bhaskar's thoroughly dialectical mode of thinking. Human reality consists of differentiated domains that are distinct yet internally related through acts of reference. Referential detachment thus underpins the analytical distinction between existential reality and knowledge, as well as between reality and the practices and moral evaluations oriented toward it. These domains are irreducible to one another: knowledge can never coincide perfectly with being. As Potter (2007:274, emphasis added) succinctly puts it, "knowledge is knowledge *of* something—reality".

Yet it is precisely this difference that makes relation possible. What human beings can grasp and reflect upon is not reality as such, but their relation to it. This capacity enables second-order reflection on knowledge, action, and judgement. It also grounds humanity's peculiar position within the world: because humans are simultaneously part of reality and detached from it, they can adopt a standpoint from which they reflect upon themselves, their practices, and their conditions of existence.

Together with the concept of absence, referential detachment constitutes a condition of possibility for human engagement with the world, for the production of fallible knowledge, and for

normatively oriented praxis. The moment of radical difference prevents the world from collapsing into an undifferentiated whole; the moment of relation, however, allows it to be conceived as a structured unity. Dialectical thinking, in this sense, is the attempt to think identity in difference.

Having now established these core elements of dialectical critical realist thought—constellational dialectics, absence, and referential detachment—the ground is prepared for applying them to the concrete challenges posed by FACC.

4.2 Reframing FACC through dialectical thinking

This section demonstrates how the dialectical mode of thinking developed in the previous chapter can be applied empirically to the case of FACC. The aim is to bring the field of FACC into dialogue with dialectical critical realism in a way that both reframes its core problem and generates new conceptual insight. To this end, the section revisits the three core challenges identified in Section 2.5 through a dialectical critical realist lens: first, how to conceptualise the relationship between nature and humans (Section 4.2.1); second, how to understand change in socio-ecological systems (Section 4.2.2); and third, how to conceptualise the perspective of acting human beings within this ongoing change (Section 4.2.3).

4.2.1 Complex human–nature relations: A critical realist perspective

As argued in Chapter 2, contemporary forests can be understood as complex socioecological systems in which both biophysical and anthropogenic causal powers operate (Schlüter et al., 2019). In much contemporary social theory, however, it has become fashionable to reject the distinction between nature and humans or society altogether. The common claim is that it was precisely the "modern" attempt to separate these realms that obscured their always-already hybrid character, a condition that is now becoming increasingly visible (most prominently in Latour, 1993). Critical realism departs from such posthumanist arguments by insisting on the analytical differentiation required to think the relationship between humans and nature rather than dissolving it.[24] The aim of this section is to explicate the rationale behind this move and to show how it can be productively employed in the analysis of FACC.

During the early development of CR, relatively little attention was paid to society's relationship with non-human nature or to the ecological crises that intensified in the late twentieth century.

[24] I use the term *humans* rather than *society* in the expression human–nature relations because my analytical starting point is the individual human being who is always already knowing and acting in a changing world. This does not deny the decisive influence of social structures that shape this relationship. In German-language scholarship, this perspective is often captured by the concept of *social relations with nature* (*Gesellschaftliche Naturverhältnisse*, see e.g. Görg, 1999), which is highly compatible with CR in its focus on the dialectical relation between nature and society. In the present analysis of FACC, I therefore also examine the social conditions that structure forestry practice and subject them to critical scrutiny (see Chapter 8).

Bhaskar later acknowledged that he wished he had "thematise[d] in a more systematic and perhaps dramatic way the ecological crisis" (Bhaskar and Hartwig, 2010:142). From the late 1990s onward, however, environmental philosophers and political ecologists began to draw explicitly on CR in their critiques of social constructionist accounts of nature (e.g. Soper, 1995:157–160; Proctor, 1998; Benton, 2001; Forsyth, 2001).

More recently, CR has been applied to a wide range of environmental issues, including nature conservation (Carolan, 2006), genetically modified organisms (Carolan, 2008), Earth system and ecosystem theory (Price, 2019, 2023), sustainable development (Høyer and Naess, 2008), environmental justice (Cobs-Muñoz and Westerholt, 2025), climate change (Bhaskar et al., 2010), and interdisciplinarity (Høyer and Naess, 2008; Bhaskar et al., 2010). Together, these contributions demonstrate the usefulness of CR for debates centred on the human–nature problematic.

On the one hand, CR affirms—alongside authors such as Latour (1993, 2000)—the materiality and causal efficacy of non-human nature, thereby resisting the idealist tendencies of strong social constructionism (see especially Benton, 2001; Carolan, 2005; van Koppen, 2017). Bhaskar (2008:192) explicitly warns against the anthropic fallacy, defined as the "exegesis of being in terms of human being," and characterises much traditional philosophy as marked by a "deep-seated anthropocentrism" (Bhaskar, 2010:39).

On the other hand, CR remains critical of many posthumanist and new materialist approaches—such as Actor-Network Theory or assemblage theory—that reject analytical distinctions in favour of a flat ontology (Elder-Vass, 2008; Porpora, 2017; Rutzou and Elder-Vass, 2019; Knudsen, 2023). From a critical realist perspective, the elimination of analytical differentiation undermines explanatory power. If everything is equally agentic in the same sense, it becomes difficult to account for emerging and qualitatively different kinds of causal powers.

In this respect, CR converges with Malm's (2018, 2019) critique of hybridism and his defence of an "analytical dualism" (Archer, 1995:15) between nature and society. Malm argues that humans and nature emerge from the same material reality yet possess different properties: "If society has no properties that mark it off from the rest of the world—what we insist on calling nature—*how can there be such an awful amount of environmental destruction going on?"* (Malm, 2018:59, his emphasis). This position resonates strongly with Bhaskar's constellational thinking: society is emergent from biophysical nature, contained within and dependent upon it, yet irreducible to it and endowed with distinct causal powers capable of acting back upon nature (Bhaskar, 2008:229; Sayer, 2019).

One of the most sophisticated critical realist attempts to conceptualise this stratified relation is offered by Carolan (2005), who distinguishes three layers of nature: (1) discursive constructions of nature (e.g. wilderness narratives), (2) socio-biophysical phenomena (e.g. forests shaped by both natural and social processes), and (3) physical-causal phenomena (e.g. gravity,

photosynthesis). While this framework usefully highlights emergence and stratification, it remains primarily sociological, focusing on how society relates to different layers of nature rather than on the dynamic interplay between biophysical processes, knowledge, and practice in concrete situations.

Carolan later addressed this limitation by proposing a triadic heuristic for environmental analysis comprising an ontological dimension (what exists), an epistemological dimension (how it is known), and a moral dimension (what ought to be done) (Carolan, 2008). He argues that environmental problems are often treated as purely ontological matters addressed by natural science, while their epistemological and moral dimensions remain marginalised. Although this move advances beyond positivist framings, the three dimensions are presented largely as parallel and insufficiently theorised in their internal relations. Moreover, the framework leaves open whose standpoint is represented within each dimension.

Combining Carolan's insights with DCR allows these limitations to be overcome. Forest ecosystems under anthropogenic climate change can be understood as constellations—or "meshworks of material beings" (Bhaskar, 2008:49)—in which multiple kinds of causal powers interact. Humans, as embodied material beings, are part of this meshwork. At the same time, they possess emergent powers such as reflexivity, intentionality, and collective organisation that enable them to transform biophysical processes, climate change being a paradigmatic example. As Bhaskar (2008:161) puts it, "society is materialized ultimately in virtue of embodied intentional causal agency reacting back on the kinds of materials out of which it was formed."[25]

Human beings and social entities are therefore analogous to biophysical entities in being material, but not reducible to them. They exhibit additional emergent properties, including the capacity to take second-order stances toward actions, relations, and institutions (Elder-Vass, 2008, 2015). Consequently, although nature and society are always already internally related in concrete contexts—such as actual forests, knowledge about forests, and forestry practices—they remain indispensable analytical categories denoting different kinds of causal powers operating within the same open system.

Maintaining and thinking through this duality enables the identification of a constellational, internally related, and emergent whole (Norrie, 2010:ch. 4). Complexity, from this perspective, is not an undifferentiated entanglement but a stratified unity of interacting causal forces (Reed and Harvey, 1992; O'Sullivan, 2004; Byrne and Callaghan, 2023). Empirical research into socio-ecological systems such as FACC therefore focuses not on merely asserting that humans and nature are

[25] To speak of nature, as Soper (1995:132–133) succinctly formulates it, is to speak of "those material structures and processes that are independent of human activity (in the sense that they are not a humanly created product), and whose forces and causal powers are the necessary condition of every human practice, and determine the possible forms it can take." I return to the notion of the possible in Section 4.2.3.

related, but on identifying which causal powers emerge from their interaction in specific contexts and how these powers shape concrete outcomes. The following section turns more directly to this problem by examining the notion of change in complex socio-ecological systems.

4.2.2 Change, temporality and emergence in socio-ecological systems

The focus of this study is not merely the exploration of the dualism and relation between nature and society, but more specifically the complexity of socio-ecological systems. As noted earlier, and as several authors have argued, CR has strong affinities with complexity and systems thinking (Reed and Harvey, 1992; O'Sullivan, 2004; Mingers, 2011, 2014; Byrne and Callaghan, 2023; Price, 2023; Porpora, 2024). In particular, the notion of emergence provides a powerful heuristic for capturing the interrelations of multiple causal powers operating across different strata of reality:

> The blunt point is that non-linearity is a product of emergence. We need to start from emergence and develop a science that fits that crucial aspect of complex reality (Byrnes and Callaghan 2022:13).

To recall, emergence describes the diachronic process through which novel causal powers arise from specific relations among the parts of a system—powers that would not exist if these parts remained in isolation (see Section 3.1.1). Emergence thus refers to a "*particular stable organisation* or configuration of lower-level entities" (Elder-Vass, 2010:23, his emphasis) that gives rise to higher-level entities and their causal powers. In the present case, forests and their capacities (for example, stabilising slopes against erosion) are grounded in relatively stable but historically produced relations between biophysical processes and social practices, as well as in the entities that populate both domains.

However, as developed in Chapter 2, FACC is not primarily characterised by the stability of these relations, but by their transformation over time. This makes it necessary to examine more closely how change itself emerges within socio-ecological systems.

In everyday language, change refers to the fact that something is different from what it was at an earlier moment—for example, today's weather differs from yesterday's. Such differences are usually assumed to have causes (for instance, a shift in atmospheric pressure). Analytically, then, change involves three inseparable elements: temporality, difference, and causality (Bhaskar, 2008).

Beginning with temporality: time—together with space (Massey, 2005)—is commonly regarded as one of the fundamental dimensions of the world. Time is conventionally differentiated into past, present, and future. The past consists of what has already occurred and cannot be altered; the future consists of what is not yet and therefore remains to be made. As Bhaskar (2008:235) puts it, "[t]he/a/some future is real as (generally, increasingly) shaped possibility of happening (and of coming to be determined)." The duality between past and future is thus a duality between

determinedness and contingency, or closedness and openness. Importantly, this is not a rigid dichotomy: openness is always conditioned by elements of closedness, and vice versa (Næss, 2019).

From this perspective, change "is not an ontological category apart from structure and event; it just is structure (or thing), considered under the aspect of its story—of formation, reformation and transformation—in time" (Bhaskar, 1986:215). The present is the moment in which inherited structures and contingent events intersect. It is shaped by the past, which is therefore always already within it, while simultaneously oriented toward the future, which is likewise present within it as possibility (Bhaskar, 2008:132). The present can thus be understood as an "indefinite boundary state" (Bhaskar, 2010:54) in which determinate being takes event-form.

Differences between events over time constitute change. Where difference is absent, stability appears. Yet even stability is better understood as a particular form of change, insofar as the absence of difference can itself be interpreted as a difference in the pattern of variation. At the same time, "[c]hange presupposes a continuous something [...] that has or undergoes the change" (Bhaskar and Hartwig, 2016:116). The patterned unfolding of how past structures condition present events and shape future possibilities can be described as process.

Processes of change always involve both the emergence of new forms and the disappearance of others. Change, in this sense, "is the absenting of what was in favour of the emergence of what now is" (Norrie, 2010:15). If the future consists of multiple open possibilities, then most of these possibilities will not be actualised. Absence is therefore intrinsic to any conception of change: "change presuppose[s] the category of absence" (Hartwig, 2007a:13). To regard change and the future as real thus requires recognising absences as real as well. Because such absences correspond to unrealised potentialities grounded in specific causal conditions, Bhaskar (2008:4) refers to them as "determinate absences."

Absences are not best understood as isolated events, but as ongoing processes of absenting. What drives these processes is the shifting configuration and activation of causal powers in relation to one another. At particular moments, interactions among causal powers may generate contradiction—for example, when different tendencies point in incompatible directions. Yet it is precisely through contradiction that a transformation of the system becomes possible (Bhaskar, 2008:52).

Space, time, and causality thus form a "tensed tri-unity" (Bhaskar, 2008:105) of process within which entities acquire their identities relationally. A tree's existence, for instance, is constituted through its spatial location, its temporal becoming, and the causal mechanisms sustaining it.

Likewise, a human being occupies a "position within the system of changing differentiations and differentiating changes" (Bhaskar, 2008:224).[26]

In this sense, change is not only the thematic focus of this study on forest adaptation to climate change; it is a fundamental feature of reality itself. Historicity characterises social life, but it also characterises nature, as recognised at least since Lyell and Darwin. Building on the previous section, social change and natural change are therefore necessarily interconnected. Human beings and societies, through their embodied and socially conditioned powers, can shape—but never fully determine—their futures.

Applied to FACC, any attempt at forest adaptation begins from what already exists: inherited forest structures, institutional arrangements, and forms of knowledge. Yet adaptation also involves the absenting of elements of the past in order to enable the emergence of new configurations. Analysis must therefore attend simultaneously to the persistence of the past in the present and to the presence of the future as possibility within the present. Focusing analytically on this "presence-of-the-future-in-the-past-in-the-present" (Bhaskar, 2008:132) helps to render the complex temporality of socio-ecological change more intelligible.

The crucial point, however, is that all agents are themselves embedded within these processes. No Archimedean standpoint outside change is available. Change exceeds individual actors and, as evident in the climate crisis, also exceeds society as a whole. Yet individuals and societies do not stand outside change; they act within it. What this implies for agency, and how such action can be conceptualised, is the focus of the next section.

4.2.3 The axiological moment as a field of possibilities

In the present case of FACC, the crucial point—identified as the third problem in Section 2.5—is that action is always undertaken from *within* a long-term and potentially unlimited process of change. Inevitably, knowledge about this change is incomplete and partial. Yet individual action nonetheless proceeds through knowledge, and in acting, individuals intervene in their contextual world and contribute to its transformation. Bhaskar conceptualises this reciprocal interplay of knowledge and action as the axiological moment. It is "the spot from which [one] must act" (Bhaskar, 2008:8): a moment in which one confronts "the necessity of the world in an open context" (Hartwig, 2007d:47).

What makes this moment possible is the dialectic between causal structures and openness. If everything were predetermined, no action would be necessary; if everything were entirely open,

[26] Here one can observe similarities with Actor–Network Theory and Deleuzian Assemblage Theory, both of which emphasise that entities can only be understood relationally within transiently stabilised networks or assemblages. The crucial difference is that, for CR, relationality does not negate the existence of real causal powers operating independently of human cognition (Bråten, 2022; Elder-Vass, 2008; Rutzou and Elder-Vass, 2019; Rutzou, 2017).

action would have no causal efficacy and would therefore also be unnecessary. This does not imply that individuals can freely shape the future according to their will. Other beings and forces—including other people—possess causal powers that constrain and interact with one another. Every action is therefore possible only in relation to these other beings and causal forces. These ever-shifting relations constitute the flow of time. The individual confronts this changing world and must respond to it in the present.

What one thus continually encounters is a world of possibilities—or, in abstract terms, the possible. Like the notion of change, the possible is an everyday concept. It can be defined as that which is neither wholly determined nor wholly undetermined: "the potential results of a process are neither unlimited nor predetermined" (Nellhaus, 2025:3). While the opposition between the possible and the determined is intuitive, the contrast between the possible and the indeterminate is less so. If the world were completely indeterminate, it would dissolve into an undifferentiated blur lacking spatial or temporal differentiation. Everything would collapse into sameness, leaving no room for alternatives. The possible, by contrast, affirms the multiplicity of alternative futures latent within the present. Or, as Byrne and Callaghan (2023:4) put it with regard to complexity: "there are multiple possible states for the future of a complex system, but these are limited in the possibility (phase) space."

This can be further clarified through the dialectic between presence and absence. In a purely positive world—where everything is always already present—there would be no space for the possible. Conversely, in a purely negative world, possibility would vanish along with everything else. The possible—and with it, change—thus emerges from a dialectic between the positive and the negative.

The possible always refers to something not present in the here and now. As Norrie (2010:38) puts it, "what is presently absent shapes what is to come." At the same time, not everything that is possible will come to be. Once a possibility becomes actual—once it is realised—it loses its status as possibility and enters the domain of the determinate. In doing so, it sublates (cancels) other coexisting possibilities as well as elements of what previously existed.

Just as the possible is tied to absence, it is also bound up with ontological depth. It always refers to a moment in the space–time continuum other than the immediate present. While the present was once a possibility, it is now fixed and without alternatives—it cannot be changed. Yet the possible arises only in relation to the present. For something to be possible, it must be at least dispositionally inherent in present structures (Bhaskar, 2012a:196–198, 2012b:47–48). Conversely, whatever exists at a given moment must previously have been contained within the potentialities of causal powers. Hence, to paraphrase Deleuze (1994:208)—whose concept of the virtual shows certain affinities with what is here called the possible (see DeLanda, 2013; Nellhaus, 2025)—the possible "is opposed not to the real but to the actual." The possible is therefore "real because realizable" (Archer, 2019:239), while exceeding what is actual at any particular moment.

This means that the possible is rooted in the present while always extending beyond it. Only in this way can novelty and change occur—whether in natural, social, or socio-ecological domains: "Nature is indeed related to the creation of unpredictable novelty, where the possible is richer than the real" (Prigogine, 1997:72). The possible thus has ontological priority over the actual: "how could anything be manifest in actuality which was not first a possibility?" (Bhaskar, 2012b:47–48). The existence of the possible therefore constitutes a basic condition for change: "History [change] enters the universe when the space of the possible is much larger than the space of the actual" (Kauffmann, 2009:xii).

Returning from these abstract considerations to the axiological moment—the perspective of the acting human being—an agent encounters a field of possibilities in which both their own agency and their relation to the socio-material context of action are decisive (Archer, 2000). Other causal forces are always operative: physical forces (such as gravity), social power relations, institutional structures, and more. Ultimately, however, it is the possible—and the corresponding field of possibilities—that enables human practice, emancipation, and thus change itself. As Bhaskar (2012b:48) notes, "there are some things which it is possible for people to be, become or do which they are not at present, whether they are constrained by extraneous heteronomous forces or whether it is just simply something they have not yet become or done" (see also Patomäki, 2006).[27]

With respect to the temporal dimension of change, it can therefore be said that "we, and entities generally, may be said to contain possible futures within us, and these may be vital to our being" (Bhaskar, 2008:132). For individuals who are always already acting, a field of possibilities implies both compulsion—the necessity to decide in the face of openness—and freedom—the capacity to redirect the course of events. Agency is thus simultaneously a necessity and a possibility. In this sense, a possibility can be understood as a concrete utopia: a way of identifying "real, but non-actualized, possibilities inherent in a situation," capable of generating "grounded hope to inform emancipatory praxis" (Bhaskar, 2010:84; see also Archer, 2019). Hence, "where acting is possible, it is also in one sense always necessary" (Norrie, 2010:220). The axiological moment is where the possible fuses with the necessary—where opportunity and constraint intersect.

Applied to a socio-ecological system such as that found in FACC, this means that the states such a system can assume are finite and limited: "Anything does not go" (Hannah, 1999:31). Accordingly, the knowledge that can be acquired about the system is also finite. Yet the development of the system is neither determined nor predictable; it remains open and subject to change. Individual elements within the system—including human beings—derive their properties relationally.[28]

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[27] At the same time, the possible should not be confused with fantasy or arbitrariness. The possible always exists in relation to a specific context.

[28] Here, insights from quantum mechanics are particularly suggestive for systems thinking. Three aspects are especially relevant: (1) physical reality is granular, meaning that there is a finite number of states a particle—and therefore also a system—can occupy; (2) it is impossible to know in advance which state a particle or system will assume next; and (3) particles determine their states only in relation to other particles—

The possible, then, constitutes an emergent layer of a socio-ecological system from a specific and limited temporal position—namely, the present—which is itself defined relationally. Actors within this system encounter a field of possibilities. In this regard, the possible can be understood as the constructive and affirmative counterpart to uncertainty.[29]

With the concept of the possible, I have established an analytical lens through which to re-examine the problem of practice within ecological change. The next step is to refine this concept so that it can meaningfully capture the dynamics of a concrete empirical case of FACC, while remaining open—or indeterminate—enough to be shaped through the analysis itself. This is the task of the next section.

4.3 Towards a conceptual framework for investigating FACC

Building on the identification of the conceptual tools of dialectical critical realism (Section 4.1) and their application to the core issues in FACC (Section 4.2), this section translates these discussions into a framework for empirical investigation. Section 4.3.1 operationalises the notion of the possible into analytical tools, offering a conceptual framework for examining empirical material. Section 4.3.2 then defines the research questions guiding the examination of the empirical case. Section 4.3.3 situates the study within the broader academic landscape, and Section 4.3.4 outlines the metatheoretical foundations underpinning the framework.

4.3.1 Operationalising the possible: A conceptual framework

In the previous section, I developed the concept of the possible—and the corresponding field of possibilities—as a heuristic tool for understanding how always-already-knowing actors confront a changing world. This perspective enables engagement with the core problem in the field of FACC—namely change, and the role of knowledge and practice within it—in a comprehensive yet non-reductionist manner. To render these theoretical ideas more tangible, it is useful to return to

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that is, events always occur relationally within and between systems (Rovelli, 2017:101–105). See also Elder-Vass (2025) for a critical realist interpretation of quantum mechanics and its compatibility with realist accounts of the material and social world.

[29] The notion of multiple possible outcomes is widespread in the uncertainty literature within and beyond forestry. It appears, for example, in definitions of uncertainty as "the presence of multiple possible outcomes or explanations"(Brown and Damery, 2009:83), or in calls for "using approaches and modeling tools to assess as large a range of possible outcomes as possible instead of the traditional mainly deterministic and static modeling tools" (Messier et al., 2016:150). Such discussions, however, typically address possibility in the abstract language of modelling, rather than from the perspective of a relational understanding of humans in the world and the associated processes of knowledge production and practical action. In this respect, Reinhold et al. (2025:2) take a further step toward articulating an ontology and epistemology of the possible when they argue that: "Rather than being fixed by universal truths, many things in our society are neither necessary nor impossible; something that can be as it is, was or will be, but is also possible in a different way."

the central issues at stake. As outlined in Section 2.2, three key questions structure the current scientific literature on FACC: (1) What might future forests look like? (2) How reliable is existing knowledge about these futures? (3) Which management strategies are recommended in light of these future scenarios?

From the perspective of the possible, these questions point to three distinct dimensions: the first refers to a field of possibilities in the biophysical world; the second to a field of possibilities in knowledge about that world; and the third to a field of possibilities in practice—that is, in the activation of human causal powers. These dimensions are deeply interdependent: what can be done depends on what is known, and what the forest will become depends partly on what is done. Nevertheless, they provide a useful heuristic grid for analytically engaging with the problem.

To apply this analytical framework empirically in a case study of FACC, these three dimensions must be further differentiated. Drawing on dialectical critical realist thought, I propose three dialectics through which they can be operationalised in a case-specific manner. These dialectical pairs function as conceptual tools for analytically grasping concrete fields of possibility within an empirical case. They must therefore remain sufficiently abstract to isolate particular mechanisms from the fuzziness of empirical reality without pre-empting or predetermining how those mechanisms operate.

With regard to the possible in the biophysical world, I propose the critical realist dialectic between the actual and the causal (see Section 3.1.1). To recall, the actual refers to temporally and spatially manifest events and phenomena, while the causal refers to historically and spatially transcendent forces that explain these events. For Bhaskar, this dialectic concerns the analysis of being itself. In the context of this study, however, it provides a basis for apprehending how the complexity of forest ecosystems as biophysical systems is explained.

Importantly, the dialectical movement between the actual and the causal does not depict a fixed or determined reality. Rather, it examines how events in the biophysical world are explained with reference to causal powers—and, conversely, how causal powers and their interrelations are mobilised to imagine particular events. It thus concerns the ways in which ecosystem change is referenced, encompassing not only past developments but also possible future states of the natural world. This dialectic therefore addresses what I term the *natural possible*.

With regard to the dimension of knowledge about the biophysical world, I propose the dialectic between the empirical and the theoretical. As discussed in Section 3.1.2, knowledge about nature has an empirical foundation, relying on phenomena accessible through the senses. Yet this empirical basis alone is insufficient for knowledge to become transfactual—that is, meaningful beyond the immediate moment of experience. All knowledge is therefore shaped by pre-existing theoretical frameworks, which guide observation while simultaneously being reshaped by it.

Knowledge about the forest thus emerges through the interplay between these seemingly contradictory poles. What matters here is not the specific content of a knowledge claim, but the process of knowledge production: how socially embedded subjects come to assert particular truth claims, as well as alternatives to them. Such processes are not predetermined—experiences may be interpreted differently across theoretical frameworks, and theories may be mobilised to interpret divergent empirical insights. This dialectic therefore captures what I call the *epistemological possible*: a reflexive orientation toward one's own knowledge, its limits, and the emergence of alternatives.

Finally, for the dimension of practice—the activation of anthropogenic causal powers—I propose the dialectic between the actual state and the ideal state, or, to distinguish it from the natural possible, between what is and what ought to be. What is primarily captured here is desire: the intention to realise a different state of the world than that which currently exists. This dialectic therefore articulates what I term the *normative possible*.

Yet such desire is always conditioned by the present and by the causal structures that define it. In this sense, the activation of praxis presupposes both a world and knowledge of it. As Bhaskar (2008:157) writes, it "is informed desire that drives praxis on." Praxis is thus the enacted consequence of the discrepancy between the actual and the ideal. As long as the desired change is in some form practically achievable, the actual and the ideal cannot be considered separately. Any reference to what ought to be implies a process through which it might be realised under present conditions: "Ought presupposes, not implies, can" (Bhaskar, 2010:112).

These dimensions and their corresponding dialectics can therefore be understood as belonging to a single ontological layer of the possible with regard to praxis. While the dimension of the natural possible examines a reference—and thus a relation—to a world that precedes and exceeds the acting individual, the epistemological possible turns inward, reflecting on knowledge itself. The normative possible then redirects this movement outward again, conceiving the acting subject as one causal power among many within the world.

Together, these three dialectics form the conceptual framework guiding the empirical study that follows.[30] Their purpose is to explore the normative praxis in FACC and how it is embedded in both knowledge and biophysical reality. Every normative-practical act is simultaneously epistemological, and every epistemological reference is grounded in ontology. Conversely, the epistemological dimension introduces the subject as knower, while the normative dimension introduces the

[30] This three-dimensional account of the possible, or of a field of possibilities, shares certain affinities with Bhaskar's dialectical critical realist model of four-planar social being, which conceptualises social life along the dimensions of material transactions with nature, interactions between human subjects, social relations, and the inner life of human beings (Bhaskar, 2008:142–143). However, I found this model too rigid and insufficiently operationalisable for analysing the perspective of acting subjects, particularly because it does not explicitly incorporate the layer of the possible.

subject as agent. Ontology, epistemology, and ethics are thus considered not in isolation but relationally.

These dialectics make it possible to conceptualise FACC not as fixed or closed but as fundamentally open and indeterminate—structured by real mechanisms yet rich in possibilities. The possible is therefore not limited to the range of actions available to actors, nor to the social processes through which these options are negotiated. Rather, it encompasses what can be, what can be known about it, and how these levels relate to action and its social embedding.

4.3.2 Research questions

The conceptual vocabulary developed around the notion of the possible enables the three central questions outlined in the previous chapter to be reformulated into a single guiding research question suitable for empirical investigation: **How does the possible future forest emerge?**

Given the long temporal horizons inherent to forestry, this question addresses two interrelated concerns. On the one hand, it seeks to understand how actors grasp what can be—how they appropriate the possible within a temporally limited present. On the other hand, it examines how the forest is shaped through this realm of the possible—how actors intervene in the world in determinate ways to bring about particular futures. The focus therefore shifts to the relationships and structures through which the possible forest takes form, emerging from the practices of knowing and acting subjects. The aim is not to determine what is possible in any fixed sense, but to understand how the possible itself emerges through engagements with fluctuating moments of openness and closure oriented toward the future. Accordingly, the possible forest is conceived as an emergent layer within the complex socio-ecological system, possessing its own causal powers.

Analytically, this overarching question can be differentiated into three interconnected perspectives. These reflect the relational constitution of the possible and examine its emergence: (1) in relation to the biophysical world, (2) in relation to the acting individual within this world, and (3) in relation to the acting individual as socially embedded.

These perspectives are articulated through the following research questions:

(1) How is change in the forest ecosystem epistemically grasped and made tangible?

This question adopts the standpoint of the knowing actor and concerns their reference to a temporally and spatially situated biophysical world—that is, the interplay between observable events and the causal forces that underlie them. Any such reference necessarily involves an epistemological dimension, whether explicitly acknowledged or not; even the absence of a declared epistemology implies a particular knowledge stance. Accordingly, this question mobilises both the natural possible and the epistemological possible, as well as the interaction between their respective dialectics defined in the previous section.

(2) How is individual practice made possible under conditions of forest change?

Here, the normative dimension of the framework comes to the fore. Praxis is understood as the activation of an actor's embodied causal potentials, driven by normative commitments. This question explores how individuals enact change, how they are enabled or constrained by existing conditions, and how their actions relate to desired futures. Practice is thus situated between what is and what ought to be, conditioned by both current biophysical realities and actors' commitments to transform them. Accordingly, this question mobilises the normative possible alongside the other two dimensions.

(3) How is the space of the possible forest simultaneously enabled and constrained through social relations?

This question shifts the focus from the individual to the social dimension. Recognising that actors are always socially embedded, it investigates how broader societal conditions enable and constrain individual action—in other words, how the field of possibilities is both opened and delimited by social structures. The emphasis lies not on isolated actions but on relational dynamics among actors. While retaining the focus on the dimensions of the possible, this question applies them at a collective level by examining how relations between actors shape the field of possibilities.

By framing these research questions through the lens of the possible, the study enables an investigation of the causal powers at work in the field of FACC. This conceptual framing supports the analysis of an empirical case within a unified structure, foregrounding how actors relate to the world, to knowledge, and to normative goals. In doing so, it provides the basis for a deeper interpretation that moves beyond the superficial notion of perception toward a more reflective understanding of how—and in what directions—anthropogenic causal forces may be meaningfully activated.

Before turning to the empirical case study, however, the next two sections situate the present conceptual framework in relation to existing research fields and explore its potential for dialogue with other (meta)theoretical strands in the social sciences.

4.3.3 Situating the research in the academic context

The conceptual framework presented in Section 4.3.1 not only facilitates a nuanced understanding of the multidimensional challenges observed in the FACC case but also positions this study within broader academic debates on contingency and structure, particularly in relation to complexity and transformation in socioecological systems. As has become evident, the central conceptual challenge lies in grasping these apparent opposites dialectically.

Each of the three dialectics proposed in the conceptual framework is organised around a tension between an element that imposes structure and another that expresses contingency and

processual emergence. The spatio-temporal actuality of the biophysical world encountered by individuals is marked by difference, transformation, and indeterminacy, yet is simultaneously shaped and constrained by interacting causal forces. Knowledge of reality emerges from the interplay between what is encountered empirically and the interpretative frameworks that lend structure to observation. Similarly, human practice is embedded in contingent contexts while oriented toward normative horizons—that is, toward what might be altered in being through the causal powers of human agency.

Through its triadic and overlapping dimensions, the framework conceptualises the possible as the central constitutive element of the axiological moment. As articulated here, the possible always contains both a structuring abstraction and a concretely structured component. Without some structuring principle, the notion of possibility would collapse into incoherence: if everything were possible, no stable temporal or spatial relations between events could exist (for instance, a green, damp forest could instantaneously become a pink desert or an orange ocean). Such randomness is neither experientially plausible nor theoretically defensible, as it would undermine the very conditions for intention, coordination, and action. Consequently, equating the possible with pure indeterminacy is logically self-defeating.[31]

The space of the possible described here is therefore bounded on one side by the impossible—what is entirely absent—and on the other by the definite—what already exists. It emerges in the interstitial space between these poles through the relations among the causal powers at work in the world.

Accordingly, this framework situates itself within academic currents that prioritise relationality and processuality. This orientation resonates strongly with geographic scholarship (e.g., Massey, 2005; Glückler and Panitz, 2021; Yeung, 2024:chs. 4 and 5), complexity theory (O'Sullivan, 2004; Byrne and Callaghan, 2023), and research on socio-ecological transformations (West et al., 2020). At the same time, the framework adheres to a realist ontology within geography, treating relational and processual aspects as features of real being rather than merely discursive constructions (Hannah, 2005; Sayer, 2006).

In contrast to poststructuralist tendencies in human geography and anthropology—which often resist notions of dualism, reality, causality, and structure—this study reclaims these concepts

[31] It is crucial to distinguish between structure (or causal power) and determinism. The existence of causal structures does not imply that "for everything that happens there are conditions such that, given them, nothing else could happen" (Bhaskar, 2003:154). Rather, structures refer to the possibility of events, not their necessity. Characterised by transfactuality, causal powers operate independently of any particular time or place while becoming actualised in specific contexts. Structures both enable certain outcomes and constrain the realm of the possible by excluding the impossible. As Bhaskar (2008:295) humorously illustrates: "Why cannot a Member of Parliament suddenly start to bear prunes? It is physically impossible, by virtue of his genetic constitution, for an MP, while retaining his essential structure as a human being, to sprout prunes—even on a Saturday afternoon."

and proposes to think them dialectically (Harvey, 1996:ch. 2; Demeritt and Dyer, 2002; Sheppard, 2008). Likewise, against contemporary strands of anthropology and social theory that conflate ontology and epistemology (e.g., Carrithers et al., 2010; Kohn, 2013; Viveiros de Castro, 2015), the present approach treats these dimensions as distinct yet interrelated and mutually constitutive.

In this way, the study aligns with philosophical traditions that emphasise becoming while subjecting the radical fluidity found in such approaches—exemplified by Deleuze—to critical realist scrutiny. Norrie (2010:204–205), for example, critiques Deleuze's actualist metaphysics for dissolving causality into pure difference. Nellhaus (2025) extends this critique by arguing that even Deleuze's notion of the possible—derived from the concept of the virtual—remains constrained by material structures, and that its causal efficacy is intelligible only through such structuration. From this perspective, becoming can be understood as the continuous activation of underlying structures (what Deleuze terms "differentiation"). A critical realist understanding of becoming therefore does not privilege becoming at the expense of being; rather, being and becoming are seen as internally related (Norrie, 2010).

Rutzou and Elder-Vass (2019; see also Rutzou, 2017) similarly compare critical realism's structure-oriented ontology with Deleuzian assemblage theory, advocating a synthesis in the form of a dynamic and non-reductive realism. This points toward a promising space of dialogue between ontologies of structure and those of fluidity.

The present approach also intersects with philosophical movements rejecting post-Kantian idealism, loosely grouped under the labels "new realism" or "speculative realism." While these perspectives do not deny human cognitive capacities, they challenge the privileging of human consciousness over the rest of reality. As Harman (2010:174) observes:

> Whether we deny things-in-themselves outside the human/world correlate, or insist upon such extra-mental realities, this endless dispute orbits the single dismal pair of human and world. The relation between just these two terms is treated as the magic key that will unlock all the secrets of ontology if solved.

Bhaskar nevertheless criticised this movement, arguing that "the realism of the speculative realists has mainly concerned the existence of things, not the operation of their causal powers; it is a realism about things rather than (also) about causality and hence the activity of things" (Bhaskar and Hartwig, 2016:39). Indeed, approaches such as Harman's often invoke a flat ontology in which structures and power relations—in both nature and society—risk being overlooked.

The work of Hartmut Rosa (2017, 2020) likewise connects the present study to dialectical and realist variants of relationism that acknowledge the influence of social structures and the world. Like the conception advanced here of subjects as always already knowing and acting, Rosa describes individuals as being "placed in the world" (*In-die-Welt-Gestelltsein*, Rosa, 2017:150), continually required to relate to it. For Rosa, the social emerges from dialectical relations between

humans and the world—not from radical separations but from the quality of resonant relations. Such resonance, however, is increasingly threatened within the accelerating and alienating conditions of late-modern capitalist societies.

Furthermore, this framework intersects with scientific approaches that explore indeterminacy in biophysical systems. Scholars in chaos theory (Prigogine and Stengers, 1984; Prigogine, 1997), ecological complexity (Levins and Lewontin, 1985; Holling, 1996), and quantum theory (Rovelli, 2017) likewise argue that nature is neither fully predetermined nor entirely open. As Holling (1996:733) famously notes, "ecosystems are moving targets, with multiple potential futures that are uncertain and unpredictable." Such an ontology implies an epistemology attentive to uncertainty, surprise, and openness (Faber et al., 1992)— echoed by Prigogine (1997:57): "I have always considered science to be a dialogue with nature. As in a real dialogue, the answers are often unexpected—and sometimes astonishing."

The critical realist foundations of the framework are not without criticism. Chalmers (1988) questioned Bhaskar's transcendental argument for relying on the presumed stability of natural science—a premise that may not hold indefinitely. Hannah (1999:18) criticised Bhaskar for offering an underdeveloped account of the epistemological subject, while Cruickshank (2004) found his use of "ontology" insufficiently precise, an issue partially addressed in Bhaskar's later distinction between philosophical and scientific ontologies (see next section). Brereton (2004:273) warned that the search for a unified theory of the world may obscure its plural and conflictual character. Harman (2009:195–196), meanwhile, argues that Bhaskar's alternative conception of causality does not fully escape linearity but relocates complexity from the world to its analysis.

While these critiques cannot be examined in detail here[32], they remain important. Critical realism invites critique as part of its own intellectual development, and I return to some of these points in the concluding discussion of the framework's value.

Finally, it must be acknowledged that the conceptual framework elaborated here has not yet been empirically tested. Assessing its heuristic potential—its capacity to illuminate concrete cases—remains the task of the chapters that follow.

4.3.4 Philosophy and empirical inquiry: Bridging theory and research

Before presenting the empirical case of FACC, it is useful to recapitulate why this study engages so extensively with the—admittedly abstract—philosophy of critical realism and Bhaskar. This is particularly important because philosophical and theoretical reflection is sometimes dismissed

[32] A more detailed discussion of critiques of CR can be found in Mingers (2014:22–27).

in parts of the social sciences, as evidenced in strands of positivist sociology or empiricist anthropology.[33]

discourseThe issue gains further significance in light of ongoing debates surrounding the notion of ontology within and across philosophy and the social sciences (see, for instance, the exchange between Viveiros de Castro (2015) and Graeber (2015), as well as the synthesis offered by Turska and Ludwig (2023)). At its core, this debate concerns whether reality is singular or multiple, and correspondingly whether there can be one ontology or several competing ontologies as theories of reality (see also Bråten, 2022).

Bhaskar offers important terminological clarifications that help address this question. As discussed in Section 3.1.1, Bhaskar—in his role as a philosopher of science—retroduces from the ways scientific practices produce facts the necessary conditions for such practices to be possible. This leads to his distinction between *scientific ontology*, which articulates "the *specific contents* of the world," and *philosophical ontology*, which delineates "the *general categorial form of* the world presupposed by the nature of scientific (or other) activities" (Bhaskar, 2008:99, his emphases).[34]

For Bhaskar, this distinction marks the boundary between the empirical sciences—both natural and social—and philosophy (see the similar argument made by Turska and Ludwig, 2023). Crucially, scientific ontology is never equated with reality itself; it is always a theory—an articulated system of propositions that refers to the world (see also Graeber, 2015:15). One may therefore speak of multiple scientific ontologies, each representing an epistemologically mediated articulation of reality's contents. These ontologies remain fallible, and the very capacity to recognise their fallibility suggests the existence of a single reality whose basic form philosophical ontology seeks to capture through retroductive reflection on science and other forms of knowledge production.

For social scientific inquiry, this conceptual move enables a double-hermeneutic approach to the empirical study of human reality. By inverting Bhaskar's analytical procedure, researchers can use general philosophical categories to interpret how individuals articulate and relate to the world. While Bhaskar employs the term "scientific" to describe this form of knowledge production, it may reasonably be extended to encompass any human activity that engages with reality—arguably, all social practice.

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[33] This impression draws on my experience of conducting doctoral research within a highly interdisciplinary environment; see also Section 5.3.2.

[34] Within this general ontology, Bhaskar (1986:36–37) further distinguishes between ontology$_1$ ("propositions in the general [philosophical] theory of being") and ontology$_2$ ("propositions in the transcendental theory constituted by reflection on the presuppositions of scientific activities"). Scientific ontology, philosophical ontology, and ontology$_2$ all fall under the umbrella of general ontology (ontology$_1$). Ontology, in this broad sense, refers to "whatever pertains to some distinctively philosophical (or scientific) theory of being" (Bhaskar, 1986:37). A concise overview of these terminologies can be found in Hartwig (2007h).

Through philosophical abstraction, theoretical propositions can thus be developed to interpret other people's theoretical propositions about reality. Importantly, this does not grant direct access to reality as such. Rather, it allows researchers to examine how individuals—through both theoretical and practical means—refer to and construct understandings of particular aspects of being. The social scientist does not investigate the referent (reality itself) but acts of reference: how people conceptualise and relate to the world. These acts are themselves part of reality and can exert causal influence.

In this sense, philosophical thinking—especially in the form of transcendental reasoning—provides concepts that function as heuristic tools for interpreting empirical aspects of reality. Philosophy, however, is neither self-contained nor detached from the world. As Bhaskar (2008:12, his emphasis) writes:

> [T]here can be no philosophy as such or in general, but only the philosophy of particular, historically determinate, social forms. It is philosophy's other, its *topic*, securing premises for its arguments and potential referents for its conclusions, which both historically *roots* it and establishes *its* syncategorematic and *this-worldly* character, so that it ceases to consider itself privileged by some special (high) subject-matter or (superior) mode of truth.

In other words, philosophy depends upon its empirical counterpart—upon reference to a particular moment in an open-ended and differentiated world. The world retains the causal capacity to resist theory-driven interpretations; it can, in Bhaskar's (1998:8) words, "surprise us."

For a conceptually informed empirical investigation of social reality—as this study of FACC seeks to provide—engagement with critical realist philosophy therefore performs a dual function. It operates as a "methodological underlabourer for, and occasional midwife to," empirical research on the social world (Bhaskar, 1986:22), while simultaneously enabling critical reflection on the conceptual schemes that structure social scientific practice itself.

4.4 Conclusion: Rethinking FACC through the possible

In this chapter, I have demonstrated how central strands of dialectical critical realism—particularly the logic of thinking in dualities and the core concepts of absence and referential detachment—can meaningfully contribute to addressing the challenges of the field of FACC. By reinterpreting its three central problem dimensions, I have sought to render them more analytically precise.

Through the lens of the axiological moment, I argue that the concept of the possible emerges as both a sharply defined and flexible analytical tool. It enables a clearer differentiation between the ontological, epistemological, and normative-practical dimensions of possibility, as reflected in

the research questions outlined in Section 4.3.2. With this framework, I bring the axiological necessity to act and thus normativity into the analysis of the socio-ecological system in FACC (Price, 2019). Moreover, this axiological orientation is linked to transcendental realism, which insists that not everything empirically measured or "perceived" is necessarily real.

This three-dimensional conception of the possible allows for a more nuanced analysis of change in the case of FACC than broader notions such as perception, attitudes, or values alone permit. Most importantly, it moves beyond description to offer insights into causality. The concept of the possible thus enables to grasp not only what is empirically "perceived," but also how such perceptions are connected to deeper layers of the real, how they are epistemically situated and reflected upon, and how human agency may be mobilised in response. In this sense, the conceptual framework presented here may be understood as a mid-range theory: "theoretically coherent and empirically relevant" (Yeung, 2024:120).

CR therefore promises to be a logically consistent, self-reflexive, and adaptable theoretical approach for rethinking FACC. It does not prescribe outcomes but instead creates the conditions for understanding and transformation. At the same time, FACC—as viewed through the lens of CR—emerges as a compelling site for exploring key ontological and epistemological dynamics of current times. The fact that biophysical nature—historically regarded as a stable counterpart to social fluctuation—is now undergoing profound change compels both individuals and societies to reassess their relationship to it. Moreover, because forest change unfolds across extended timescales and within deeply complex systems, a complete or final overview remains unattainable.

In light of this complexity, relationality and processuality become essential analytical entry points for understanding FACC. Here, the concept of the possible opens up a distinctive analytical space: it enables a reinterpretation of the problem, the recognition of its structural constraints and contingencies, and thereby contributes to shaping what may become possible within this field. Ultimately, investigating the possible is inseparable from the pursuit of freedom—for freedom lies in recognising the possible and in the capacity to act upon it.

Chapter 5: Methodology: Investigating the possible forest

Having opened a new conceptual perspective on forest adaptation to climate change (FACC), it is now necessary to explore what this lens reveals in a specific case. To echo the language of the previous chapter, I ask what this perspective makes possible. Following the theoretical and conceptual reflections, I thus turn to an empirical case. This chapter therefore outlines the methodological framework through which the possible forest is investigated empirically.

Critical realism does not prescribe a fixed methodological programme; rather, it is anti-foundationalist in methodological terms and has been described as a "philosophy in search of a method" (Yeung, 1997:51). Nevertheless, it is helpful to briefly revisit the methodological implications of the theoretical discussions thus far.

Since causality is the central element shaping both the natural and social worlds, critical realism holds that the social sciences "*can be sciences in exactly the same sense, though not in exactly the same way*, as the natural ones" (Bhaskar, 1998:174, his emphasis). Society is likewise real and structured, and the causal mechanisms operating within it can be known and used to explain phenomena such as practice. Hence, like the natural sciences, the social sciences seek to link empirical investigation with theory construction.

The key difference from the natural sciences lies in the nature of these structures: social structures, unlike natural ones, depend upon the actions of individuals. They exist only through agents' activities and the meanings attributed to those activities; they persist only in relation to these actions (Bhaskar, 1998:42). Furthermore, because social scientists are themselves agents embedded within society—that is, not entirely external to the objects they study—social research must be conducted differently from natural science, where objects are assumed to exist independently of the observer (Sayer, 1992; Bhaskar, 1998; Sayer, 2000; Danermark et al., 2002).

The ambition of social science, then, is to do justice both to the conceptuality (or concept-dependence) and the transfactuality (or generality) of its subject matter (Bhaskar, 1998:136). In other words, it must remain compatible with both a mind-independent, stratified ontology and a mind-dependent, relativist epistemology: the idea of a world that exists independently of human thought alongside the recognition that our knowledge of this world is always partial, situated, and fallible—and may even react back upon its object of study.

The methodological implications of this stance are elaborated in the following sections. I begin by focusing on the relationship between conceptuality and transfactuality in the context of case study research, where I introduce and discuss the specific case at the centre of this study (Section 5.1). I then outline the empirical investigation of this case, detailing the procedures of data collection and analysis (Section 5.2). Section 5.3 clarifies the research interest pursued in this study

before reflecting on my own positionality—that is, how my background as a socially embedded and individually acting researcher has shaped the conduct and interpretation of this research. Finally, Section 5.4 returns to the research questions outlined in the previous chapter and synthesises the study's research interest.

5.1 Research design

In this section, I outline the overall research design adopted in this study—case study research—and discuss its aims as well as its analytical potential for generating transfactual insights (Section 5.1.1). I then introduce the case of Valais and describe it in empirical terms (Section 5.1.2), before explaining the reasons for its selection (Section 5.1.3).

5.1.1 Case study research

This study on forest adaptation to climate change follows a case study research design. Case study research has a long interdisciplinary tradition and typically aims to explore a specific case—or a small number of cases—in qualitative depth (Harrison et al., 2017). It is therefore often considered the counterpart to quantitative research paradigms, which seek to generate generalised claims about causal relationships based on large numbers of repeatable cases or events. However, as discussed in Section 3.1.1, a constant conjunction of events provides neither necessary nor sufficient evidence of causality. It is thus mistaken to assume that only quantitative research can establish causal insights, highlighting the suitability of the case study approach for this investigation.

In fact, qualitative case studies are particularly well suited to contributing to the development of general theories—that is, theories with significance beyond the immediate case at hand (Flyvbjerg, 2006). It is precisely the uniqueness of a case that constitutes both the condition and the starting point for arriving at general theoretical insights and for legitimising those insights (Steinmetz, 2004:383). The particular thus stands in a dialectical relationship with the universal; it is only through difference that sameness becomes intelligible.[35]

The inferential process that enables this form of knowledge is best described as abstraction rather than generalisation (Sayer, 1992:3; Yeung, 1997:58–61; Sayer, 1998; Lund, 2014). Whereas generalisation seeks to build theory from recurring patterns, abstraction entails identifying and isolating specific causal mechanisms within a particular case through the use of concepts (Lund, 2014).

From a critical realist perspective, abstraction refers to the intellectual movement between the empirical and actual domains and the real—that is, from observable events to the deeper

[35] For further discussion of this dialectic between the particular and the universal, which cannot be elaborated here, see Bhaskar (2008:104–124) or Norrie (2010:ch. 4).

generative mechanisms that produce them. Explaining a concrete phenomenon involves isolating in thought the causal powers that interact to produce observable outcomes (Sayer, 1992:86–96, 1998; Danermark et al., 2002:41–70). In constant interplay with its dialectical counterpart, concretisation, abstraction enables both theory construction and a deeper understanding of the specific case. This is not a practice unique to the social sciences; the natural sciences likewise rely on abstraction (see, for example, Levins and Lewontin, 1980:66–67).

In this regard, a case always stands for something beyond itself. Case study research therefore aspires to transfactuality, which, in critical realist terms, refers to the aim of making statements that go beyond actual, factually given situations and instead address the level of the real—that is, causal powers that exist beyond the moments in which they are actualised. Methodologically, this involves "seeing something as something else" (Danermark et al., 2002:93). It is precisely this movement between concepts and the empirical case that constitutes the heuristic value of case study research (Lund, 2014). Crucially, the conceptual framework and the empirical case remain distinct, yet only through their dialectical relationship—in their dialogue (Steinmetz, 2004:391) — can they generate amplificative (i.e., content-expanding and practically adequate) knowledge (Sayer, 1992:ch. 2).

The application of concepts prevents the researcher from producing purely idiographic descriptions that remain confined to the observable and offer no pathway beyond it. Conversely, anchoring inquiry in empirical material prevents a purely logocentric approach, where conclusions are merely deduced from pre-established concepts. The interplay between the two enables theoretically rich and empirically grounded insights. In this sense, case study research—and the analytical process of abstraction it supports—should be understood as neither inductive nor deductive, but abductive (Timmermans and Tavory, 2022).

The concept of abduction originates with Charles S. Peirce (Reichertz, 2004; Timmermans and Tavory, 2022:15–16), who defined it as a form of inference in which a surprising fact (C) is explained by a plausible hypothesis (A): "The surprising fact C is observed; but if A were true, C would be a matter of course; hence, there is reason to suspect that A is true" (Psillos, 2007:257). In qualitative social research, the identification of the relationship between A and C is mediated by the theoretical frameworks employed, which assign central importance to concepts in data analysis (see Section 5.2.2). However, as discussed earlier, causality in critical realism cannot be equated with determinism. Abductive inference therefore always involves interpretation, linking specific observations to one or more possible causal mechanisms. This makes the knowledge gained fallible, as it is conditioned by the conceptual framework employed. Yet it is precisely this interpretative movement that opens up new insights into why observed reality takes the form that it does (Danermark et al., 2002:90–91).

The case (or cases) enables empirical observation and allows conceptual tools to exercise their heuristic function. When case selection is guided by the aim of evaluating and developing

concepts—in other words, facilitating abductive inference—the strategy can be described as paradigmatic (Flyvbjerg, 2006:232–233).

Such selection is not random. It should be guided by prior knowledge and expectations—bearing in mind that all knowledge is necessarily situated and always understood in relation to one or more knowing subjects. In short, case selection must attend both to spatio-temporal singularity and to the potential for generating abductive insights. In the following section, I introduce a case that paradigmatically captures the central issues of FACC and explain how and why it was selected on the basis of specific prior knowledge.

Before doing so, however, it is worth recalling that I have already enacted this movement from the abstract to the more concrete in Chapter 1. The field of FACC itself was selected because it is paradigmatic of broader research into change in complex socio-ecological systems.

5.1.2 Case description

As announced in the introduction (Chapter 1), the case study examined in this research is the Upper and Central Valais regions in the Swiss Alps.[36] This mountain valley was shaped geomorphologically during the Ice Age by the Rhône Glacier and is now defined by the river of the same name. The main valley runs roughly east to west and features several side valleys, primarily to the south. Forests mainly cover the slopes of these valleys (see Figure 3, p. 80). Elevation ranges from approximately 500 metres above sea level in the lowest parts of the main valley to mountain peaks exceeding 4,000 metres.

The Valais region's climate varies strongly with altitude. High elevations experience an alpine mountain climate, characterised by long, cold, snowy winters and short, cool summers. In contrast, the lower areas have a continental climate (Werlen, 1994:607), with cool winters, hot summers, low precipitation, and intense sunshine. This varied topography and climate create a rich diversity of vegetation and forest types. Above the forest line (around 2,000 ± 300 metres above sea level), alpine grasslands and meadows dominate, while dense forests cover most areas below. Mountain coniferous forests—comprising spruce (*Picea abies*), larch (*Larix decidua*), and Swiss stone pine (*Pinus cembra*)—are prevalent at mid-elevations, whereas deciduous species such as oaks (*Quercus* spp.), maples (*Acer* spp.), and whitebeam (*Sorbus aria*) become more common at lower altitudes. Beech (*Fagus sylvatica*), widespread in other parts of Switzerland and Central Europe, is largely absent in Valais due to its low drought tolerance. Scots pine (*Pinus sylvestris*), by contrast, thrives in the dry lower elevations and is often dominant (Werlen, 1994, 1995). On the south-facing slopes of the main valley, a lower forest line exists due to extreme dryness and heat, leading to open landscapes of grasses, herbs, and shrubs known as the Valais

[36] Although this study focuses exclusively on Central and Upper Valais (see Figure 3, p. 80)—specifically, the area extending roughly from Sierre to Goms—the term *Valais* is used throughout for the sake of simplicity.

rocky steppe (see Figure 4, p. 81). This spatial heterogeneity contributes significantly to the region's high biodiversity.

Switzerland has experienced a warming of approximately 2.9°C since pre-industrial times (as of 2024), more than twice the global average, and further warming of between 1°C (if the global 1.5°C target is met) and 2.9°C (under roughly 3°C global warming) is expected relative to the reference period 1991–2020 (MeteoSwiss and ETH Zurich, 2025). For Valais, even the moderate climate change scenario RCP 4.5 projects a temperature increase of approximately 3°C by the end of the century, alongside a decrease in summer precipitation of about 10% relative to the 1981–2010 average (see Figures 5 and 6, p. 81). The temperature increase is particularly pronounced in the lower, already warm and dry areas of the main valley during summer (see Figure 7, p. 82).

As a consequence of this warming, vegetation zones and habitat ranges of tree species are expected to shift upward by roughly 300 to 700 metres by the end of the century, depending on the scenario (Theurillat and Guisan, 2001:89; Frehner et al., 2018:8; Zischg et al., 2021) (see Figure 8, p. 83). Forest boundaries will likewise shift. However, forest adaptation takes time: seeds must disperse and new trees must grow. If existing trees can no longer tolerate the changing climate, they will eventually die.

Tree mortality has already become evident in Valais in recent decades, particularly among Scots pines. Scientific studies have identified summer drought as a major factor influencing this dieback (Rigling et al., 2002; Bigler et al., 2006; Eilmann et al., 2006; Hunziker et al., 2022). Given climate change—which increases the likelihood of drought periods, even if annual precipitation remains roughly constant—attention is increasingly focused on the future viability of Scots pine (Rebetez and Dobbertin, 2004). At the same time, this species has increasingly been replaced by the more drought-resistant downy oak (*Quercus pubescens*) (Rigling, Dobbertin, Bürgi, Feldmeier-Christe et al., 2006; Rigling, Dobbertin, Bürgi, Gimmi et al., 2006; Rigling et al., 2013).

Forest fires also pose a growing risk (Pezzatti et al., 2025). While generally limited in extent, major fires occurred in Valais in 2003 (near Leuk) and 2011 (near Visp), weakening the forests' protective function. These burned areas now serve as research sites for studying ecological succession following major disturbances (Moser et al., 2010; Wohlgemuth and Moser, 2018).

Due to these phenomena and the region's dry climate, Valais has become an "open-air laboratory" for studying forest–climate interactions and is often referred to as Switzerland's "early warning region" for climate change (Eidg. Forschungsanstalt für Wald Schnee und Landschaft, [no date]a). The Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), part of the Federal Institute of Technology Zurich (ETHZ), is the central scientific body conducting forest research in the region.

At the same time, forests play a vital role for the local population, which is German-speaking in the upper parts of the valley and French-speaking in the lower parts. Of the canton's 120,000

hectares of forest, 87% are classified as protective forests (Kanton Wallis, [no date]a). These forests prevent slope erosion and protect infrastructure—buildings, villages, roads, and railways—from landslides, rockfalls, and avalanches. Their preservation is therefore a matter of public interest.

Over the past 150 years, forest area in Switzerland—and particularly in mountainous regions such as Valais—has increased, mainly due to the abandonment of cultivated land (Bundesamt für Umwelt and Eidg. Forschungsanstalt für Wald, Schnee und Landschaft, 2025:30). However, under climate change, mountainous protective forests may lose or weaken their protective functions (Moos et al., 2021). While forest responses vary regionally, dry and warm areas are especially vulnerable to declines in ecosystem function (Elkin et al., 2013; Mina et al., 2017). Mountain regions such as Valais are therefore expected to be among the most vulnerable to climate-change-induced extreme events, requiring a high adaptive capacity from local communities (Ingold et al., 2010).

Because they are classified as protective, these forests are subject to specific management restrictions—clear-cutting, for example, is prohibited. They are therefore not managed as intensively as the even-aged forests found in some large-scale areas of Northern Europe. Instead, management typically consists of minimal interventions, such as felling individual trees or creating small canopy gaps, with the aim of fostering mixed, multi-layered, and thus stable forest stands (Wehrli et al., 2007). This work reflects centuries-old forest management practices in the Alps (Bertogliati, 2016; Johann, 2022) and is monitored and subsidised by national and cantonal governments, as it is often not financially self-sustaining (see especially Chapter 8).

In Valais, most forests (86%) are owned by so-called *Burgergemeinden* or *Burgschaften* (in French and English: *bourgeoisies*—not to be confused with the Marxist term), legal entities composed of local families holding "Burger" status, typically long-established village residents (Kanton Wallis, [no date]a). Forest ownership in Valais thus occupies an intermediate position between private and public ownership.

For management, the 141 Burgergemeinden have joined other forest owners to form 30 forest districts, supported by the cantonal government (Kanton Wallis, [no date]a). Each district has a full-time forester (*Revierförster*, *garde-forestier*[37]) responsible both for forest oversight and for managing a forestry enterprise whose employees conduct fieldwork such as logging and protective measures. Typically, these district foresters complete an apprenticeship in forestry followed by a university degree in forest engineering. Despite state support for protective forest management, forestry enterprises operate according to a certain private-sector logic and are therefore vulnerable to declining returns from traditional timber production (Ingold and Zimmermann, 2011). Given

[37] To my knowledge, all district foresters currently holding these positions are male; I therefore refrain from using gender-neutral language in this context.

the spatial complexity of the area, interventions must be carefully targeted and cannot be applied uniformly. Each forest district manages roughly between 1,500 and 7,000 hectares of forest.

The forest districts are supervised by the cantonal administration, which oversees forest use. While every Swiss canton, including Valais, has its own forest law, this is subordinate to national legislation. The first Swiss federal forest law was passed in 1876—one of the earliest in the world—with the goal of protecting forests against overexploitation and maintaining their protective function in mountainous regions, thereby following the paradigmatic idea of sustainability described in Section 2.1 (for historical context, see Mather and Fairbairn, 2000; Bertogliati, 2016). Today, the Federal Office for the Environment (FOEN) monitors compliance with federal law and ordinances, while legislative authority lies with federal and cantonal parliaments. In principle, forests in Switzerland are freely accessible to the public, and although there is no general obligation to manage them, the management of protective forests is regulated and subsidised by the federal government.

Historically, forests in Valais have not only served protective purposes. They have long been shaped by human use—timber harvesting (primarily for local purposes rather than interregional trade), forest grazing, small-scale slash-and-burn agriculture, and the collection of non-timber forest products (Loup, 1960; Gimmi and Bürgi, 2006). Forest reserves for biodiversity conservation (Kaeser et al., 2013) also play an important role in Valais, including the Aletsch forest (near Brig) and the Pfyn forest (near Leuk).

Given these centuries of human influence and the local population's dependence on forest functions, Valais can be conceptualised as a socioecological system, as introduced in Chapter 2. At the same time, climate change presents significant challenges for the future of forestry in the region. The key question for the local population is therefore how to respond to this change.

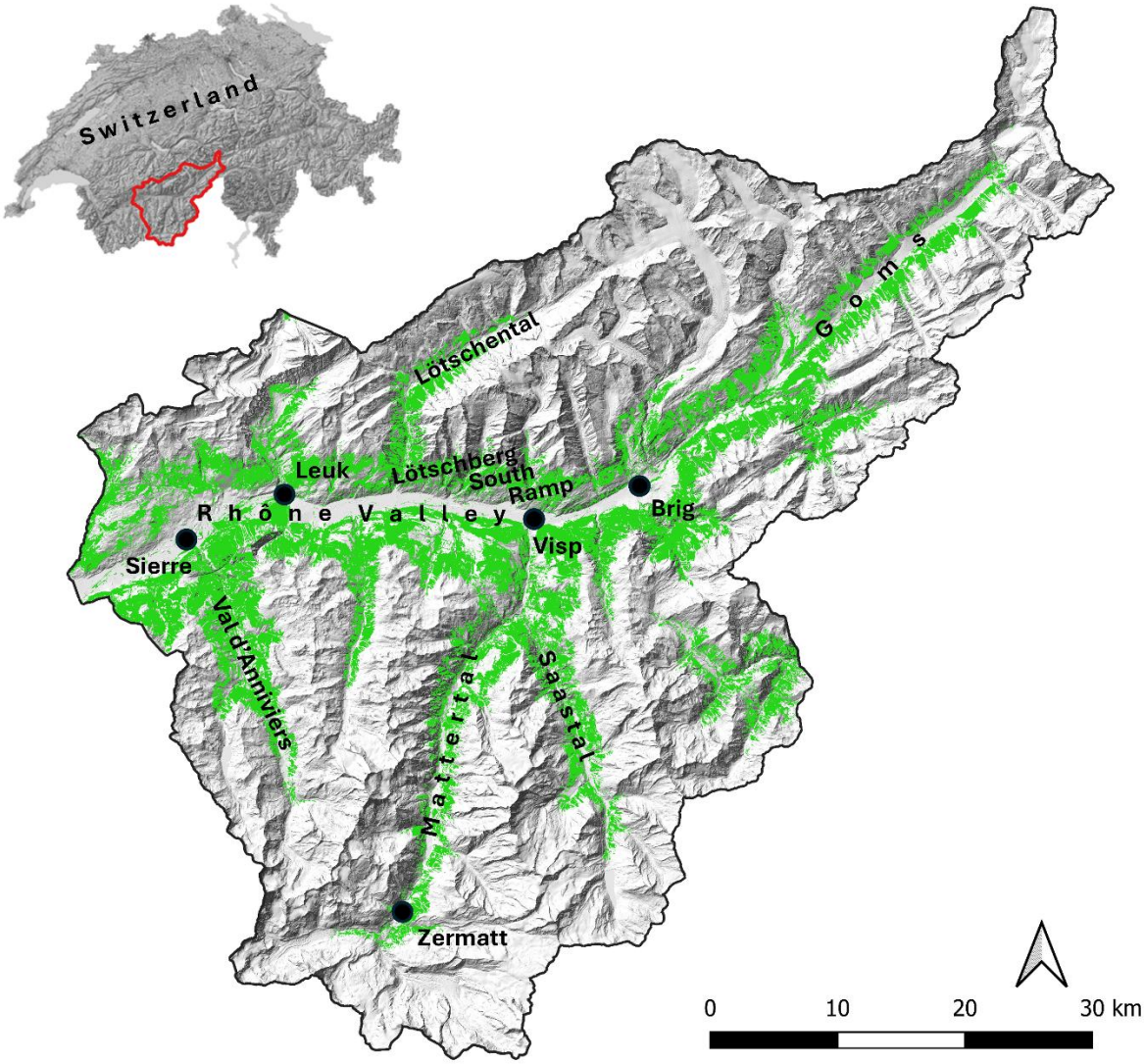


Figure 3: Map of the case study region in Central and Upper Valais showing a hillshade derived from a digital elevation model in grey and current forest cover in green. Named places correspond primarily to those mentioned in the text (Source: Author; layers "swissalti3d" and "swisstlm3d," Schweizerische Eidgenossenschaft, [no date]a).

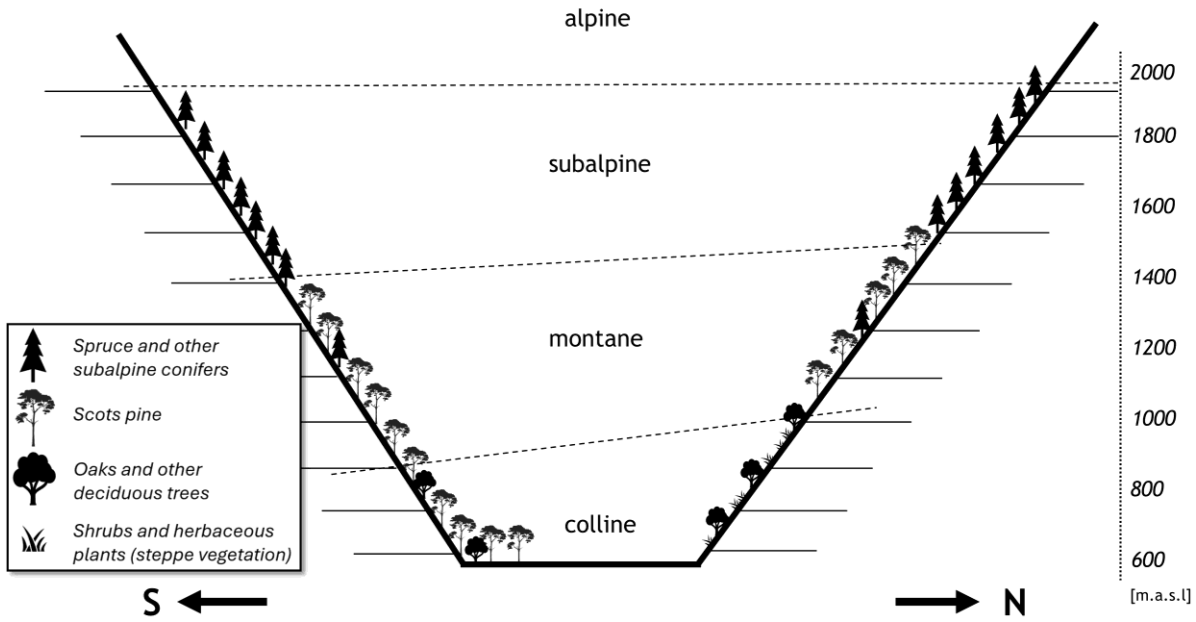
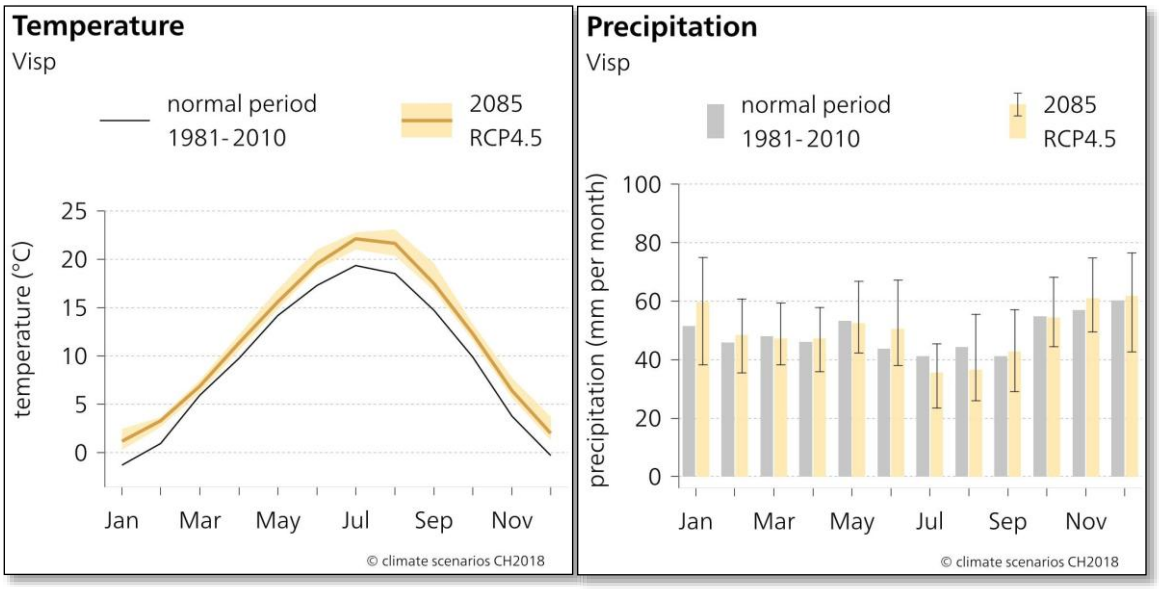


Figure 4: Simplified scheme of the vegetation belts and corresponding forest types in the main valley of Valais, according to altitude and exposition (Source: Author, based on Métral, 2015, and the author's field experience).



Figures 5 and 6: Climate diagrams for the town of Visp (Valais), showing observed mean values for 1981–2010 and a modelled projection for 2085 under a moderate climate change scenario (RCP 4.5) (Source: Schweizerische Eidgenossenschaft, [no date]b).

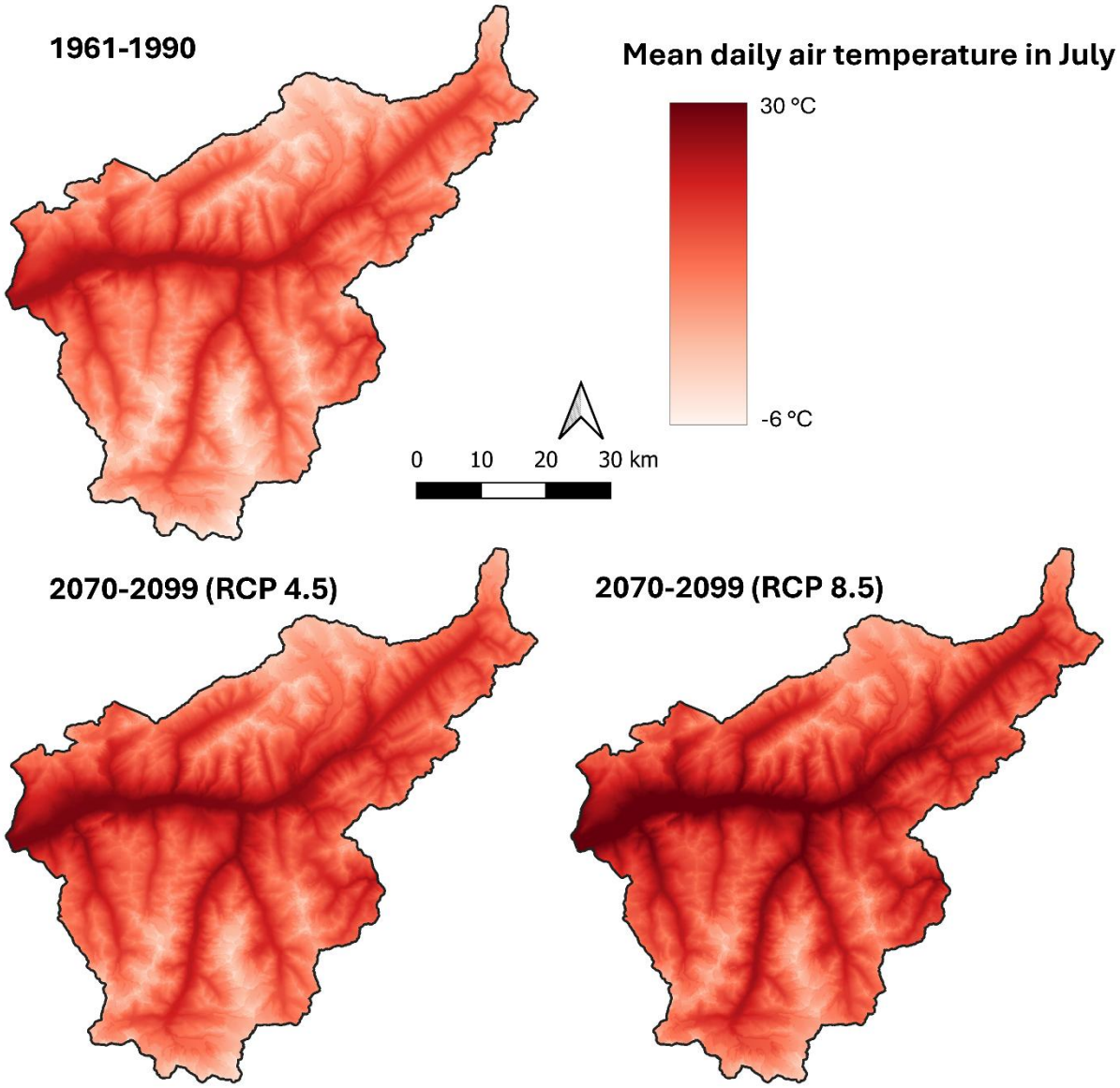


Figure 7: Mean daily air temperature in July for the case study region for 1961–1990 (based on observations) and projected temperatures for 2070–2099 under the RCP 4.5 (moderate climate change) and RCP 8.5 (strong climate change) scenarios. (Source: Author; layer "wald-lufttemperatur_juli" for the respective periods/models, Schweizerische Eidgenossenschaft, [no date]a).

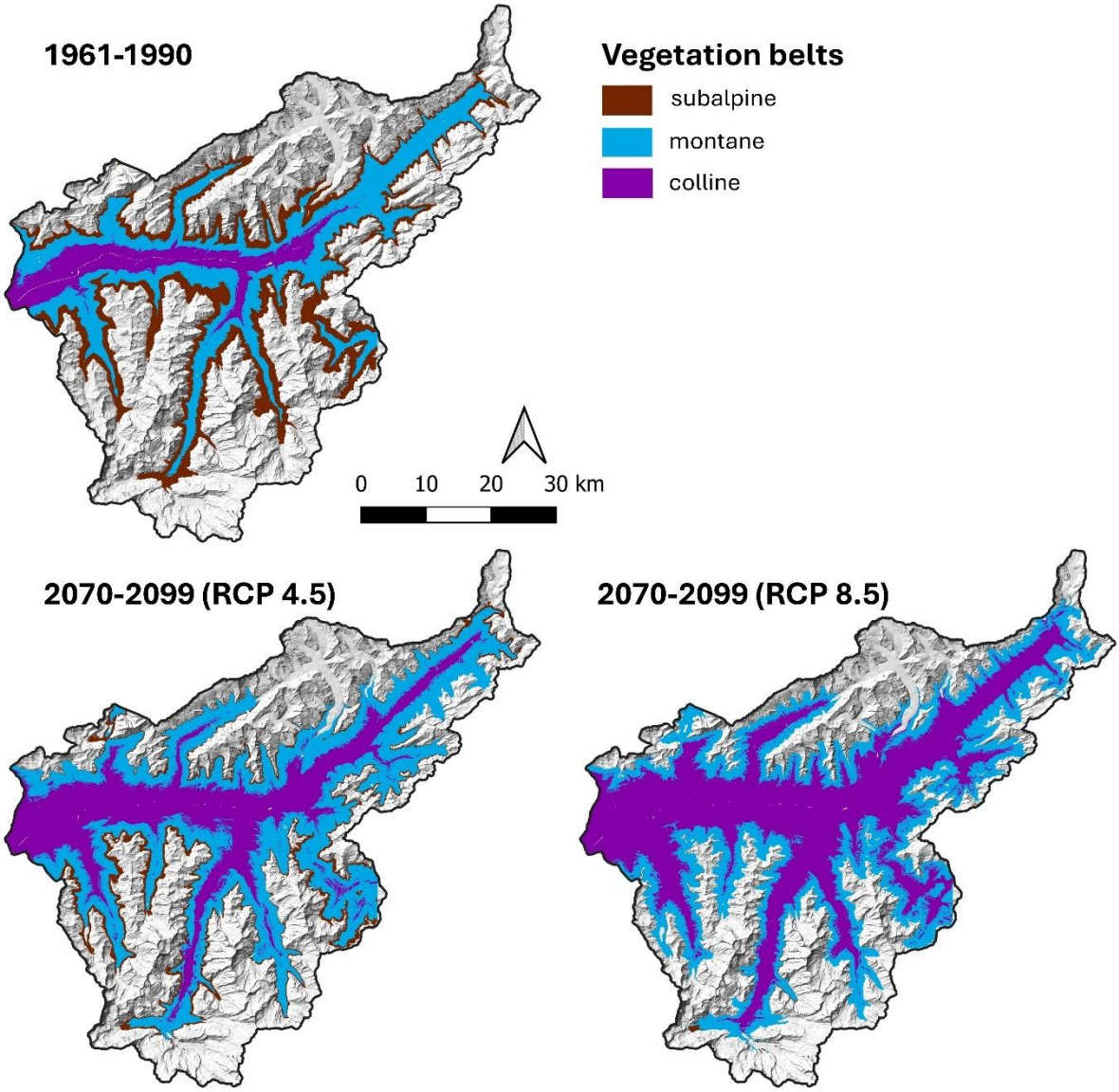


Figure 8: Vegetation belts with forest cover in the case study region for 1961–1990 (based on Frehner et al., 2005) and modelled vegetation belts for 2070–2099 under the RCP 4.5 (moderate climate change) and RCP 8.5 (strong climate change) scenarios (based on Zischg et al., 2021). The belts were simplified to correspond to Figure 4 (p. 81). The figure highlights the projected expansion of the colline belt, currently the lowest vegetation zone in the Central Alps. (Source: Author; layers "swissalti3d" and "wald-vegetationshoehenstufen" for the respective periods/models, Schweizerische Eidgenossenschaft, [no date]a).

5.1.3 Reasons for the choice of the case

As argued in Section 5.1.1, the selection of a case is guided by its abductive—and thus transfactual—potential. In the present study, the reasons for selecting this case are manifold and interwoven. This abductive potential became fully apparent only partly in retrospect, emerging through the empirical research itself and the parallel theoretical reading, during which I recognised what Valais represents as a case. Much of this process was shaped by trial and error.

More broadly, the Alpine region can be described as a particularly compelling setting for a case study on forests and climate change. First, mountainous regions are more strongly affected by climate change than lowland areas (Pepin et al., 2022). Second, the Alps have been inhabited for centuries and have been shaped accordingly (Bätzing, 2018). They therefore exemplify the close and reciprocal interdependence between humans and nature that is central to this study. Protective forests are especially significant in this context: unlike forests used primarily for timber production, they are valued not only for their economic function but are deeply embedded in the social fabric of the region. At the same time, many natural and ecological processes in the Alps can be assumed to remain relatively intact compared to more industrialised regions, as humans and nature have co-adapted over long periods. The accelerated pace of climate change is thus affecting a system shaped by long-term interactions.

Within the Alpine region, this temporal dimension—so central to the present study—renders Valais particularly significant. As shown in the previous section, Valais has experienced a prolonged phase of gradual tree dieback caused by drought, ongoing for several decades. Unlike other Alpine regions, such as Vinschgau in northern Italy (South Tyrol), where a widespread bark beetle outbreak in 2022 triggered extensive damage, the situation in Valais is not confined to a single extreme event but forms part of a latent process. This underscores the importance of temporality. Compared to discrete events that have already occurred, this ongoing process offers greater potential for articulating what I previously described as the possible. Furthermore, as noted in the previous section, Valais has long held a prominent position in Swiss scientific research, partly due to its distinctive climatic and biogeographical conditions.

Several personal factors also influenced my choice of this case study. Practical considerations included the relative proximity of Valais to my home and workplace in Fribourg, as well as my ability to speak both of the canton's languages—Swiss German as my mother tongue and French as a second language. I also have distant family ties to Valais—reflected in my surname—and spent several childhood holidays in Goms, a high-altitude valley in the canton. However, I did not know the region in depth and had never met any of the individuals I interviewed (see next section). This absence of prior personal connections helped me avoid certain preconceptions and maintain a critical outsider perspective. At the same time, the fieldwork allowed me to learn much about the

region beyond the scope of the research and to develop an appreciation for parts of Valais previously unfamiliar to me.

5.2 Methods

This section outlines the methods used to investigate and analyse the case of Valais. It begins with a discussion of data collection (Section 5.2.1), then introduces the abductive discourse-analytical approach guiding the analysis (Section 5.2.2), and finally illustrates its application through an empirical example (Section 5.2.3).

5.2.1 Data collection: Exploring FACC in Valais

For the present case in Valais, I collected data using methods that could be described as ethnographically inspired (although what falls under the umbrella of ethnography—and toward what aims it is pursued—remains highly debated; see, for example, Banfield, 2004; Ingold, 2014). Specifically, I gathered various types of data—primarily interviews, documents such as websites, policy papers, and media articles, as well as field notes from observations and site visits—in a non-standardised yet rigorous manner. [38]

However, I did not pursue ethnography in the narrow anthropological or empiricist sense of simply describing other people and their lifeworld through participation in their daily lives (e.g., Ingold, 2000, 2014). Rather, the aim was to capture multiple dimensions and perspectives on the case in order to explore its depth—that is, the causal forces operating beyond surface appearances. I therefore followed an approach of explanatory ethnography (Porter, 2002; Banfield, 2004; Rees and Gatenby, 2014).

Data collection can be roughly divided into three, sometimes overlapping, phases.

The first phase, spanning much of 2022, was primarily exploratory. As I did not have a professional background in forestry, my interest initially stemmed from seeing it as a contemporary empirical example of ecological complexity—a topic I had engaged with in my Master's thesis on the history of ecological science. At this stage, neither the specific research topic nor the case had been fully defined.

My initial focus was on the highly complex topic of forest genetics (gene conservation, assisted gene flow, etc.) in the context of climate change. However, engagement with stakeholders revealed that this focus was both too narrow and of limited practical relevance from a forestry

[38] Rubin (2021) distinguishes between rigidity and rigor in qualitative research. Qualitative methods are less oriented toward predefined expectations regarding the type of data to be collected, yet they remain systematic in acknowledging and reflecting on the characteristics of the data obtained. This understanding aligns with my own approach, as it underscores that qualitative research is not arbitrary but capable of producing valid insights.

perspective. I therefore broadened my scope to forests and climate change more generally, although this dimension is not entirely absent from the present study (see, for example, Section 6.3.4).

Within Switzerland, Valais quickly emerged as a suitable case study, largely for the reasons discussed earlier (see Section 5.1.3). A particularly important step was the organisation of a field course for Master's students in Brig, Upper Valais, in September 2022 together with my supervisor. The course focused primarily on the forests of the Lötschberg South Ramp described in Chapter 1. Working with a local forester, we produced a report on water management and forestry in the context of climate change. This enabled me to collect a range of data—interviews with stakeholders, documents, and field notes—that later proved foundational, even though the material initially appeared somewhat "noisy," as the direction of the research had not yet crystallised.

During the second phase (approximately the year 2023), I deepened my engagement with forests and climate change in Valais by conducting a series of interviews—mostly with foresters—and collecting relevant documents (policy papers, media articles, etc.). This period also saw the initial development of the conceptual framework presented in Chapter 4. Importantly, this framework emerged through a hermeneutic back-and-forth between literature review and preliminary analysis, including repeated readings of interview transcripts. I concluded this phase once I observed a degree of data saturation, as additional interviews were no longer generating substantially new insights.

From early 2024 onward, it became increasingly clear how the conceptual framework resonated with the empirical case and what it could contribute to understanding it. I summarised the emerging results in a four-page document written in accessible, non-technical language. In a third phase (autumn 2024 to spring 2025), I shared this document with key actors and conducted some follow-up interviews based on it. I also analysed documents to deepen my understanding of the political and scientific dimensions of the topic at the national scale, bringing these into dialogue with my local observations in Valais.

Methodologically, the study relies primarily on interviews with a range of actors, broadly grouped into three categories: foresters, government employees, and scientists. These categories are neither absolute nor homogeneous, nor are they intended as a basis for statistical generalisation; rather, they serve as heuristic devices that provide contextual orientation.

Foresters mainly include district foresters in Valais responsible for planning and implementing forestry work across areas spanning several thousand hectares. Government employees refer to staff at cantonal or national administrative bodies directly involved in forest governance (though not typically senior decision-makers). At the cantonal level, they collaborate closely with district foresters, while at the national level they oversee regulatory compliance. Scientists are

researchers from natural science backgrounds working on forests and climate change within Switzerland. In total, I conducted 24 interviews.

Sampling in the first phase was highly exploratory and relied on internet research and snowball sampling. During the second phase, I contacted foresters in Valais more systematically using the canton's official website to identify forest districts, focusing on the main Rhône Valley from Goms to just below Sierre (see Figure 3, Section 5.1.2, p. 80). In the third phase, I approached individuals already known to me or identified as key actors during earlier data collection. Sampling therefore did not aim at representativeness but was guided iteratively by developing knowledge of the field (Valentine, 2005:112), which was understood as an open system in which many causal powers are at work (Sayer, 1992).

Potential interviewees were usually contacted via email with a request for an interview on "forests and climate change." Not all requests received responses. Most stakeholders were interviewed once, some twice. All interviewees are anonymised and identified only by category and number (e.g., "Forester 4").

Most interviews took place in participants' offices; some—especially during the exploratory phase—were combined with field visits, while others (primarily with scientists) were conducted online. Interviews typically lasted about one hour, with field visits extending longer. Most were recorded (with participants' consent) and subsequently transcribed, forming the primary basis for data analysis. Of the transcribed interviews, 12 were conducted with foresters, 4 with government employees, and 2 with scientists. In total, approximately 20 hours of material were transcribed—mostly manually (with Swiss German translated directly into standard German) and partly with automatic transcription software for standard German and French interviews, followed by extensive manual correction.

Additionally, I conducted several unrecorded or untranscribed interviews during the exploratory phase. While not central to the analysis, they informed later discussions. A full list of interviews is provided in the appendix.

The interviews were semi-structured and in-depth (Valentine, 2005), which—in contrast to highly standardised questions or surveys—has the advantage of enabling the exploration of the multiplicity and interaction of causal powers at work, rather than merely registering non-causal correlations (Sayer, 1992:175–203). I typically began with the question: "How do you perceive the current situation with regard to forests and climate change?"[39] For foresters, I added "in your forest." This broad opening allowed interviewees to identify what they considered most relevant, often

[39] Although the term *perception* appears in this interview prompt—despite its critique in Chapter 3.3—it should be understood as a practical conversational expression rather than an analytical category.

generating rich narrative accounts that included personal observations—for example, drought damage—used to explain management practices.

I then probed these themes further, sometimes introducing topics that had emerged in earlier interviews to explore potential causal connections (Brönnimann, 2022). As a concluding question, I often asked: "How do you think the forest in Valais will look in 30–50 years?"—a question that elicited particularly revealing responses (see especially Section 6.3).

Through this approach, I gathered perspectives from individuals directly confronted with a changing world and compelled to act, that is, to relate to the world, their own knowledge of it, and their own causal powers within it. While foresters are the most obvious actors in this regard, government employees and scientists are equally situated within specific temporal and spatial contexts that shape their engagement with change. Interviews thus constitute, on the one hand, momentary snapshots—an important consideration in a study concerned with long-term change. On the other hand, interviewees typically draw on many years of experience rather than immediate impressions. This convergence of different time scales constitutes one of the major insights emerging from these interviews (see, e.g., Section 7.3).

An interview invites actors to articulate these engagements explicitly, thereby attributing meaning to their experiences. At the same time, the open-ended format allowed interviewees to shape their responses freely, making the interaction closer to a dialogue than a rigid interrogation (Valentine, 2005).

Linguistically mediated statements in the interviews are always co-produced by interviewee, researcher, and interview setting. Without the interview, such reflections might never have been expressed. This does not diminish their analytical value. Rather, in the sense of referential detachment, language establishes connections to phenomena not necessarily present in linguistic form—such as the biophysical world, knowledge about it, and human agency. Interviews therefore enable the study of meaning-making in relational terms without collapsing the world into the meanings attributed to it (Brönnimann, 2022). They also offer a practical advantage: transcripts can be revisited repeatedly and subjected to systematic analysis (see next section).

Because participants' accounts are only "the *starting point*, but not the end, of the research process" (Rees and Gatenby, 2014:137, their emphasis), I complemented interviews with a wide range of documents, including scientific literature, grey literature (policy papers, media articles, some historical documents), and institutional websites. Many originated from scientific and administrative bodies such as FOEN, WSL, the Canton of Valais, and local forest districts. These sources often led to further literature, sometimes referenced during interviews. On one occasion, I consulted the archive of a railway company for historical materials. The *Swiss Forestry Journal* (*Schweizerische Zeitschrift für Forstwesen*) also proved invaluable.

Media articles were identified through a systematic search using "forest" and "climate change" as keywords for the period 2020–2024 on the online platform of *Swiss Radio and Television (SRF)* and the *Walliser Bote*, a local daily in Valais.[40] Additional articles were gathered less systematically from newspapers such as the *Tages-Anzeiger*, which I read regularly, as well as other media encountered during the research process. These documents served both as contextual background and as points of comparison with interview insights (see, for example, Section 8.2.3).

Unlike interviews, documents typically reflect longer, institutionalised processes involving multiple contributors, and authorship is often diffuse—especially in grey literature produced by political administrations. Nevertheless, they form part of the social world and can be assumed to exert causal influence (Mogalakwe, 2006). In the analysis that follows, they are used primarily as contextual sources but also for comparison and triangulation (particularly in Chapter 8).

Over several years, I also attended and observed public and semi-public events—such as presentations and conferences organised by scientific and political institutions—related to the topic, both in Valais and elsewhere in Switzerland (see appendix). In doing so, I adopted what Koch and Tetley (2023) describe as a perspective of *conference ethnography*. Beyond expert presentations, I observed interactional dynamics such as the types of questions posed and the ways they were articulated, documenting these observations in field notes.

Additionally, I undertook numerous walks and hikes in Valais to experience the forests directly, often visiting sites mentioned in interviews. Many of these excursions took place during my free time but nonetheless shaped my understanding—particularly of the heat and dryness characteristic of south-facing slopes. My botanical knowledge further enabled me to recognise forest structures and species compositions in situ.

In summary, the methodology pursued here does not aim to capture purely subjective mental states but rather the reciprocal relations between knowing, thinking, and acting subjects and their biophysical and socio-political contexts, with a particular focus on the structures operating within them. The field under study is therefore not narrowly confined to the geographically and politically defined unit of Valais. Instead, forestry knowledge and practice are treated as relationally embedded within political institutions, shared normative orientations, and broader ideas about the world.

Extensions and redefinitions of the field were largely guided by theoretical sensitivity and evolving empirical insights (Wolff, 2004:197). Nevertheless, the approach adopted here enables these structuring relationships to be analytically identified (Porter, 2002; Banfield, 2004; Rees and

[40] This five-year period roughly coincides with my own engagement in the field and includes the exceptionally warm and dry summer of 2022, which led to early tree discolouration and dieback across Valais and Switzerland.

Gatenby, 2014). The following two sections outline the analytical procedures used to identify these causal mechanisms and structures.

5.2.2 Transition from empirics to analysis: A critical realist approach to discourse

As argued in Section 5.1, this study seeks to trace deeper causal structures beyond empirically observed events. Since all data are, by definition, forms of events, the question arises how to move analytically from these events to the abstract, non-visible structures underlying them (Lund, 2014). Much of the data corpus for this study, as outlined in the previous section, exhibits—one way or another—the characteristics of linguistic events. My analysis therefore began with a reflection on the nature of language, which led me to discourse analysis as an appropriate approach to data analysis. Because discourse analysis encompasses many different traditions (see, e.g., Jørgensen and Phillips, 2002, for an overview), I briefly outline in this section the basic principles of the approach I employed and, in the next section, demonstrate through a concrete example how I applied it in practice.

Discourse analysis has a long tradition in the social sciences and typically emphasises the productive, meaning-generating, and power-laden nature of language (Jørgensen and Phillips, 2002). Yet it has often been criticised for concentrating too narrowly on the linguistic construction of reality while neglecting its relation to social structures and material conditions (Fairclough, 2010). This critique has also been taken up by critical realists (Fairclough et al., 2004). Bhaskar, for instance, warned of a "linguistic fallacy"—the belief that statements about the world can always be reduced to linguistic terms (Bhaskar, 1998:179, 2008:192).

However, this critique did not lead to a wholesale rejection of discourse analysis within critical realism. On the contrary, critical realists—precisely because they regard the social world as concept-dependent—have sought to develop forms of discourse analysis that are more attuned to discourse theory and semiotics (Nellhaus, 1998; Fairclough et al., 2004; Newman, 2020), while also establishing more systematic methodologies (Jones, 2004; Sims-Schouten et al., 2007). The central problem for such an approach is that there can be no "identity nor homology" (Bhaskar, 1998:156) nor "isomorphism" (Sayer, 2000:38) between non-linguistic reality and its linguistic representation—an analogue to the rejection of the correspondence theory of truth described in Section 3.1. Yet this is precisely what makes discourse analysis fruitful in the present case: linguistic expressions are always attempts to articulate the world and one's own place within it. The aim is therefore to examine how reference is made to the indeterminate—to that which is not already fixed in language. In other words, the goal is to explore the relationship between language—as an emergent and causally efficacious part of reality (Elder-Vass, 2011; Sayer, 2012)—and the non-linguistic elements of reality.

To this end, Nellhaus (1998) reintroduces the referent into semiotic discourse theory: the meaning of particular statements (such as those made in interviews) does not depend solely on the interaction between signifier and signified (as poststructuralist accounts would claim), but also on their triangular relationship to a referent—that is, to something beyond language itself. In essence, this means that "we must distinguish our talk from the objects our talk is about" (Porpora, 2015:163). Yet this independence is itself sublated—*aufgehoben*, in the Hegelian sense—once reference is made in the form of a linguistic statement.

Returning to the figure of referential detachment discussed in Section 4.1.3, language is a form of referring, and thus of relating, to something radically different from itself. Whether or in what form the referent exists independently is not the decisive issue. More important is the positive fact that an act of reference is made, which can be understood as a moment in which the radical alterity between referrer and referent—or between the self and the world—is sublated and their unity comes to the fore. This emerging act—the dialectical relationship between referrer and referent—is both caused and causally efficacious: it is, in a dialectical sense, "causally conditioned by extra-discursive aspects of social reality" and "causally efficacious on the rest of social reality" (Bhaskar and Hartwig, 2016:106). Language, or discourse, therefore possesses the productive character emphasised by poststructuralism, yet it is not the only form of causality in the world and remains constrained by linguistic and non-linguistic forces. Certain causal powers condition what can meaningfully be said in a specific moment—such as discursive orders, social norms, property relations, or even biophysical forces—while reflective, agentive human beings ultimately decide what they say in that moment (Elder-Vass, 2011).

From the perspective of individuals, statements and speech acts are thus subject to the axiological imperative, which holds that one always acts within a multiply caused world (Bhaskar, 1998:96). A linguistic act arises from an axiological moment and therefore presupposes at least an individual reason as a causal force. At the same time, as shown in Section 3.2, any form of practice or thinking presupposes a world to which such a relation is directed. Hence, behind every empirically recorded linguistic event lies a deeper realm of events and causal powers to which it relates. Moreover, in exercising this linguistic act of reference, individuals mobilise the linguistic resources available to them through their socialisation within a particular context.

Accordingly, this form of discourse analysis does not aim to examine the referent directly but rather the relationship between linguistically capable, socially embedded subjects and the world. Analysing such relationships in a concrete context, such as FACC in Valais, does not mean retracing discrete constitutive parts (e.g., referent, signifier, signified). Instead, it involves retroducing the causal powers that give rise to linguistic enunciations. A range of causal powers are always at play in the emergence of a linguistic statement in an interview or document: from the basic capacity to speak or write in a particular language, to specific reasons for making one statement

rather than another, to contextual factors such as addressees or material and non-material referents.

Discourse, in this critical realist understanding, can therefore be conceived as a hinge between agency and the structures that surpass the individual (such as social or biophysical structures) (Elder-Vass, 2011), or between the self and the world, as described in Section 3.2. I thus use it as a proxy for understanding how the possible forest emerges through a multiplicity of causal powers.

However convincing this theoretical grounding of discourse and discourse analysis may be, it says little about how the approach can be operationalised in a concrete case. The few attempts to translate it into a practical methodology (Jones, 2004; Sims-Schouten et al., 2007) were not fully persuasive for my purposes, as they focus on different empirical domains and provide limited guidance for the analytical movement between data and conceptual framework. In the following section, I therefore show how I proceeded in making this form of discourse analysis applicable to my case.

5.2.3 Data analysis: Putting abduction into practice

The theoretical discussion of language and discourse in the previous section implied the following principle for my analysis of the data in the case of FACC in Valais: I treated any linguistic statement (or set of statements) as an event arising from an axiological moment and referring beyond itself. This referent may take several forms; however, as I am primarily interested in the possible forest as an emergent and causally efficacious layer in the present case, I focused principally on that dimension of the real. Given that the corpus comprised several hundred pages of interview transcripts, documents, and field notes, the first challenge was to identify the statements most relevant to this study.

As interviews constituted the principal source of data, my first step was to read and re-read them carefully multiple times. This reading process unfolded largely in parallel with the development of the conceptual framework outlined in Section 4.3.1. It should be emphasised that this framework was by no means clear at the outset of data collection and analysis; rather, it emerged gradually through a continuous hermeneutic back-and-forth between the empirical material and the theoretical readings of critical realism discussed in Chapters 3 and 4 (on the interplay between empirical data and theoretical concepts, see Lund, 2014; Fletcher, 2017; Nichol et al., 2023).

Over the prolonged process of familiarising myself with the interviews and other materials, and in dialogue with the conceptual framework, certain keywords proved crucial for identifying excerpts that referred to the undetermined, open, and possible—for example, “can,” “perhaps,” or conditional (“if”) clauses (see Hoogstra, 2008:145–148; Hoogstra and Schanz, 2008:326–327 for further examples of such markers of uncertainty). These keywords sharpened my analytical attention,

enabling me to detect an increasing number of passages in which the possible was evoked. At the same time, I became attentive to passages where such references were absent and phenomena were instead described as clear, determined, and given.

I grouped these excerpts inductively according to recurring themes (e.g., tree dieback, plantings, pests), comparing and connecting them. For this thematic coding of text passages, I found pen and paper—occasionally supplemented by a blackboard—more useful than qualitative data analysis software such as NVivo or MAXQDA, with which I also experimented, as this approach allowed me to reread the excerpts more easily within the context of the entire interview. These themes later provided an initial structure for Chapters 6–8, where I present and analyse the data through key excerpts.

Next, I analysed each excerpt abductively by asking: What are the necessary elements for the emergence (or absence) of a particular possible? This question inverts the one posed by Schoppek (2021:151) in her "ex-ante retroduction" of alternative futures—namely, "what must be the case for a particular result to be possible" in the future. It also draws on Sayer's (1992:91) central question for realistic abstraction: "What does the existence of this object (in this form) presuppose?" Counterfactual thinking was equally important here (see Danermark et al., 2002:101), as I repeatedly asked myself: Would this still be possible (and not merely impossible or determined) if a particular element did not exist?

At the same time, this abductive analysis was not strictly systematic or procedural.[41] Abduction depends heavily on creativity (Danermark et al., 2002:81), and many insights emerged intuitively—sometimes during repeated readings, but often at unexpected moments, such as at night or while hiking in the mountains of Valais. Reichertz (2004:162–163), referring to C. S. Peirce, describes such moments leading to abductive insight as "musement" or even "daydreaming." In this regard, the ubiquity of mobile phones proved unexpectedly useful, as I often emailed myself notes when I was away from my desk.

Yet this creativity or intuition should not be confused with arbitrariness or invalid knowledge. On the contrary, creativity is indispensable to the production of new knowledge precisely because its conclusions are not, as in formal logic or deduction, already contained within the premises (Mingers, 2014:53). The conceptual framework developed in Section 4.3.1 and the research

[41] Technically, the questions and analytical strategy employed here draw on both abduction and retroduction. In practice, however, distinguishing clearly between the two proved difficult, and the methodological literature offers only limited guidance on this point. Abduction is commonly understood as the interpretation of a phenomenon within a conceptual-theoretical framework, whereas retroduction refers to the reconstruction of the structural conditions that make this phenomenon possible (Danermark et al., 2002:80). Yet if abstract concepts and theories are understood as transitive formulations of real structures (Danermark et al., 2002:23; Sayer, 1992:87–88), the boundary between the two becomes less distinct. Bhaskar and Hartwig (2016:79) similarly note that abduction can function as the starting point of retroduction, a view also acknowledged by Danermark et al. (2002:96). For the sake of conceptual clarity and readability, I therefore use the term *abduction* throughout this thesis.

questions defined in Section 4.3.2 helped to orient and discipline this creativity so that my abductive reflections did not disperse in countless directions. This analytic process—combining creativity with structuring focus—can be summarised, by paraphrasing Timmermans and Tavory (2022:1), as a systematic cultivation of surprise. Whenever such moments of surprise occurred, I returned to the abductive question of what necessary elements had produced them.

To make this process more explicit, I present here a brief demonstration using an interview excerpt. This example reappears in Section 7.2.1, where it contributes to a broader argument on the planting of climate-adapted tree species. Here, it serves as an illustration of the analytical steps:

> The question now is simply how much [climate change] will affect us. If the forecasts are correct, if we will have those five degrees more, we will slowly start to have Italian climate conditions here. We might have evergreen trees then. We could try planting cork oak or devil knows what (Interview "Forester 7(1)"[42], February 2023).

In this excerpt, several keywords and expressions refer to undetermined and open states—that is, to what I conceptualised as the possible—including "the question," conditional clauses, "might," and "could." This is why I selected it for in-depth analysis. Moreover, all three dimensions of the possible, as defined in the conceptual framework (Section 4.3.1), can be identified.

First, there are references to the biophysical world: "if we have those five degrees more, we will slowly start to have Italian climate conditions here," and "we might have evergreen trees." Here, the forester points to openness in the world beyond himself. Even though these phrases contain a human subject ("we have"), they would retain the same meaning if the subject were removed and replaced with, for example, "there is." Such statements therefore refer to a natural possible: the forester evokes conditions of openness in a world that transcends the speaking subject. At the same time, he points to events such as "Italian conditions" and "evergreen trees" that are caused by climate change—illustrating how the dialectic between the causal and the actual is at play in the emergence of the possible.

Second, with regard to the epistemological possible, the forester refers to "if the forecasts are correct." Forecasts are human-made products of knowledge, and their correctness presupposes fallibility. For the forester, they represent theoretical knowledge rather than direct experience, yet he links them to observable events (evergreen trees, Italian-like conditions). Here, the epistemological and natural dimensions of the possible intermingle, as no distinction is made between the potential existence of these events in biophysical nature and their being known. The conditional clause is followed by a statement about biophysical nature, highlighting the interwoven character of the dimensions of the possible when viewed from the standpoint of a subject embedded in an axiological moment that compels action.

[42] When I conducted more than one interview with the same person, I indicated the interview number in brackets.

Finally, I identify a normative possible in the statement: "We could try planting cork oak." Unlike the earlier "we have" statements, this "we" cannot be replaced by a passive form ("there is") without altering its meaning. It clearly refers to human subjects—the forester and his team, and potentially other foresters in the region. The possible practice emerges from the intersection of the forester's context (a warming climate), the specific characteristics of cork oak (*Quercus suber*, an evergreen tree found in Mediterranean regions of Europe that endures drought well), and his normative goal of maintaining a functional forest. Although this goal is not explicit here, it is strongly implied both by other parts of the interview and by the broader forestry context in Valais.

As this illustration shows, the three dimensions of the possible are not always equally visible in empirical data and sometimes require contextual knowledge to identify. This does not present a problem; rather, it underscores the independence of empirical material and the interpretative character of analysis—seeing beyond immediate words to what they presuppose. In presenting my empirical findings in Chapters 6–8, I therefore do not retrace every step of interpretation as I have done here but focus instead on key insights embedded within broader arguments.

A brief note on the analysis of non-interview material is also necessary. I analysed documents in the same way, although I reread them less frequently than the interview transcripts. Over time, the more deeply I engaged with the interviews, the more attuned I became to detecting passages in documents where the possible was invoked. Interestingly, as will be shown in Chapter 8, it was often the absence of references to the possible in such documents that proved most revealing. The same applies to observations from public events and the field notes derived from them.

I also sought to bring different sources—interviews, documents, and observations—into dialogue. At times this was straightforward, as interview partners referred directly to specific policy documents; at other times it required greater interpretive effort and creativity. In both cases, I analysed these materials using the same abductive questions to explore how the possible emerges through social relations. The outcome of this effort is presented in Chapter 8, where I examine how particular actors refer to and position themselves in relation to others.

Finally, it should be emphasised that the writing process itself formed part of the analysis. Many abductive insights that now structure Chapters 6–8 crystallised only through the act of writing. A coherent thread and argument thus emerged gradually as thoughts were put into words. Before presenting these results, however, I turn to a reflection on how my own positionality—both in the field and within academia—shaped the analysis and the findings of this thesis.

5.3 Situating myself as a researcher: Positionality and knowledge production

The criterion of radical otherness (Graeber, 2015) in knowledge production also applies to the part of the real I investigate—and to which I refer—namely FACC in Valais. In engaging with this reality, my own positionality inevitably played a causal role. Accordingly, this section reflects on how my position as a researcher has influenced the results of this study.

I do so, first, by examining my role in the field (Section 5.3.1), particularly in relation to the actors I interviewed. Second, I consider how my position within academia has shaped my thinking and, consequently, the outcomes of this research (Section 5.3.2).

5.3.1 Position as a researcher in the field

As discussed in Section 5.1.3, the selection of the case study was shaped not only by scientific considerations but also by personal elements linked to my own position as a researcher and beyond. These elements have influenced the present study, and I therefore clarify here the extent to which they have done so.

One specific element worth mentioning is my distant family connection to Valais. I grew up in Lucerne in Central Switzerland, but my great-grandfather came from the Goms valley in Valais. Although I no longer have direct relatives there, I often spent holidays in the area as a child and occasionally still do. I was therefore somewhat familiar with the region before beginning this research, which provided a degree of orientation and familiarity. For example, when a forester mentioned a particular place or forest during an interview, I often already knew what he meant and could picture it. At the same time, these conversations introduced me to new places that I later visited on hikes.

I also carry the surname *Zumoberhaus*, inherited from this great-grandfather. It is a typical Valais surname and was quickly recognised as such by people in the region. During interviews, I was sometimes asked about it, while at other times I raised it myself to emphasise my connection to the area. I believe that this name and family history opened certain doors, or at least facilitated acceptance by some interlocutors. Because initial contact was often made via email, recipients usually saw my name before hearing my dialect, which is clearly not from Valais, and may therefore have assumed that I was a local.

This family history also gave me a stronger sense of legitimacy in conducting research in the region. I did not feel like a stranger studying an ethnographic “Other” and then departing again. In this respect, approaching potential participants was easier than it might have been in a completely unfamiliar setting, which simplified the process of data collection.

Nevertheless, gaining access was not always straightforward. Many emails to potential interview partners remained unanswered, even after follow-ups. I came to realise that people in the field may not necessarily be interested in my research—or in research more broadly. This occasionally nourished doubts about whether I, as someone from the urban Swiss Plateau, was truly qualified to conduct research in a mountain region. In Switzerland, particularly in recent years, political debate has increasingly focused on the "urban–rural divide," a distinction that is especially salient in Valais, which often defines itself apart from the "Outer Switzerland" (*Üsserschwiiz* in the local dialect). Overcoming these concerns required considerable effort, yet they often proved unfounded in practice, as I was usually welcomed openly and generously by the people I interviewed.[43]

I encountered greater difficulties when attempting to focus on the French-speaking Lower Valais. I soon realised that my French proficiency was limited, particularly because locals spoke a distinct dialect and I lacked forestry-specific terminology in French. Ultimately, I opted for the more pragmatic solution of concentrating primarily on the German-speaking Upper Valais.

Another challenge concerned the expectation that my research should yield applied and useful contributions to the case under investigation. This expectation likely originated largely from myself, as I felt an obligation to give something back to the field in return for participants' time. At the same time, it was reinforced by experiences in the field. For example, one forester told me directly that he expected useful results from studies such as mine, and a government official kindly handed me his business card at a workshop, stating that he was eager to see my findings as soon as they became available. Moments like these were, in a sense, more difficult to process than explicit criticism because they carried implicit expectations of practical relevance.

Similar situations arose when I introduced myself as a doctoral student in geography at the University of Fribourg researching forests and climate change. Many interlocutors found it difficult to imagine what "geography" entails, requiring additional explanation—an effort complicated by the discipline's interdisciplinary character (see next section). Moreover, most forest research in Switzerland is associated with the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). The fact that I was working independently of WSL occasionally raised eyebrows, particularly among scientists and at conferences. At times, I also faced critical questions regarding my qualitative methodological approach. For instance, early in the project, a forest scientist remarked that I lacked a proper research question leading to measurable and useful results.

[43] The only exception was a forester who expressed scepticism about climate change and did not view it as a problem for forests. Instead, he described climate change as government "propaganda" intended to generate revenue and impose restrictions on forest management. During the interview, he accused me of being a government intern, despite my clear explanation that I was a doctoral student at the University of Fribourg. I remained calm and kept the interview brief. I also considered this encounter a finding in itself, which I discuss in Chapters 6–8.

These experiences—combined with the broader impression that contemporary Swiss research discourse often prioritises immediate applicability—generated an ambiguous sense of my relationship to the field. On the one hand, as outlined in Section 5.1.1, my aim was to develop theoretical insights extending beyond the specific case. On the other hand, I recognised that this objective might not align with practitioners' interests. The thought that this dissertation is unlikely to be read by practitioners (and understandably so) was at times uncomfortable.

I have not yet found a definitive way to resolve this ambiguity. However, my supervisor's frequent reminders that many of humanity's major discoveries—such as the theory of evolution or relativity—were not initially pursued for immediate practical benefit proved encouraging. Toward the end of the thesis, I also learned that qualitative social scientists in Germany had encountered similar experiences in the field of forestry, which reassured me that these concerns were not unique. At the same time, I attempted to make my findings accessible by writing a four-page summary in plain language in 2024. It should be emphasised, however, that such moments of ambiguity were occasional rather than constant.

These reflections also prompted a more critical question: where does the expectation that research must always have immediate practical utility originate? I increasingly came to view it as rooted in a broadly shared positivist worldview within Western modernity, which shapes dominant understandings of what counts as "'good' scholarship" (Koch and Tetley, 2023). I found this perspective to be present—and at times dominant—within the field of FACC in Valais, as I discuss in Chapter 8. Here, reflections on my positionality intersect with insights from the data analysis and therefore constitute a result of the study in their own right.

Finally, I briefly reflect on gender roles. Forestry appeared to be a strongly male-dominated domain. In the forest enterprises with which I engaged, nearly all positions involving practical forest work were occupied by men, while women were primarily employed in administrative roles such as secretarial work or bookkeeping. Accordingly, of the 24 interviews I conducted, only one involved a person I read as female (not a forester). For this reason, I use the generic masculine when referring specifically to the foresters I interviewed, all of whom I read as male, while employing gender-neutral language elsewhere.

In this regard, being read as male may have influenced my ability to approach foresters; like my Valais background, it may have facilitated recognition as one of "them." Nevertheless, I find it difficult to identify specific moments where this dynamic was explicit—perhaps partly because the near absence of women in practical forestry provided little basis for comparison.

In summary, my multiple positions—as the bearer of a Valais surname, as someone from "Outer Switzerland," as a geographer at the University of Fribourg and as a man—shaped both my access to the field and the knowledge produced. These positions should not be understood as external to the research but as emerging through the relationship between myself and the field. Rather

than being bracketed in an objectivist sense, they form part of the research results themselves (Wolff, 2004:197), and I have therefore incorporated them into the analysis and discussion.

Conversely, the fieldwork also reshaped my understanding of my own position. I have long considered myself someone who prefers stable structures in everyday life and tends to plan the future carefully. Unplanned events and uncertainty disrupt my routines and reduce my productivity. Encountering uncertainty in this case study—and in FACC more broadly—revealed that foresters constantly work with uncertainty and can engage with it productively. This insight motivated me to seek a deeper understanding of uncertainty both within this case and in my own life. In this sense, I increasingly identified with the field and its challenges, recognising how strongly my own personality is reflected in the topic of this work.

5.3.2 Position as a researcher within academia

In addition to the practical factors that influenced the selection of and access to the field, as described in the previous section, I also brought prior knowledge that shaped both the collection and analysis of data. During my interdisciplinary bachelor's and master's studies, I completed numerous courses in ecology and plant sciences. At the same time, I have continued to educate myself extensively in field botany in recent years and remain deeply interested in plants in my private life. As a result, I was already familiar with certain terms used in forestry (such as succession or plant community) and could readily recognise the tree species mentioned by interviewees or in documents. Understanding and using this terminology not only lent me a degree of credibility with interview partners but also enabled me to build upon these foundations and develop a deeper understanding of their practical significance.

However, I am not a forestry scientist and have no formal training in forestry. This lack of disciplinary background also shaped my data collection and analysis, as it prompted me to ask clarifying questions when unfamiliar terms arose during interviews (e.g., selection system (*Plenterbetrieb*)). Conducting the research from outside a strictly forestry-oriented perspective—with its own codes and conventions—also allowed me to approach certain elements with fresh eyes and thereby gain a more nuanced understanding of their relevance in the field.

In addition to these biographical factors, during my doctoral studies I increasingly noticed how my own positioning within the academic world shaped me as a researcher and, in turn, the results of this study. My integration into the Department of Geosciences at the University of Fribourg was particularly influential in this regard. Although the department is relatively small, it is remarkably interdisciplinary. In my immediate environment, I worked with researchers from geology, anthropology, physics, philosophy, engineering, history, and geography—both physical (natural science) and human (social science) geography.

This interdisciplinary setting required constant engagement with diverse approaches, modes of thinking, and methodological traditions. For the present work, this plurality strengthened my appreciation for critical realism as a metatheoretical framework capable of thinking the social alongside the natural sciences and of seeking to reconcile different epistemologies by sublating their contradictions.

At the same time, I became aware of the effort required to represent a particular epistemological position within academia—both within and beyond my immediate institutional environment. Over time, I found it increasingly exhausting to repeatedly defend my decision to study forests from a social science perspective while grounding the work in critical realist philosophy. At times, this produced a sense of intellectual isolation. In this respect, I gained the impression that interdisciplinarity is not always valued as highly in academic practice as it is in principle (see Næss, 2010).

Paradoxically, it was not discussions with natural scientists that challenged me most, but debates with social scientists from poststructuralist and empiricist traditions. Especially at the beginning of my doctoral studies, I was unsettled when a senior colleague remarked, “We really have to get you to abandon your dualistic way of thinking.” For a considerable period, I attempted to banish certain concepts from my vocabulary—yet these ultimately became central to this dissertation and its findings: causality, system, reality (in the singular), and even dualistic thinking.

In retrospect, I came to regard this attempt to exclude certain ideas as an empirical finding in its own right. While it may not have directly answered my research questions, it offered ethnographic insight into academic culture. I realised that academia, like the broader social world, is structured by particular codes, routines, and dogmas. Reflecting on widely held assumptions about the “freedom of academic thought” prompted me to consider more deeply the role and position of science itself—a process that remains ongoing beyond this dissertation. For the purposes of the present work, however, these reflections helped clarify, sharpen, and critically interrogate my own stance.

This reflexive awareness subsequently informed my data analysis, as it enabled me to articulate my conceptual perspective more precisely. For example, in Section 7.1, I examine the relationship between humans and nature in Valais and argue that these categories are not simply dissolved in practice—as a post-dualist view might suggest—but continue to exist, with the crucial question being how their relationship gives rise to the possible forest. At the same time, this process of self-examination fostered greater understanding and empathy for actors in the field. As will become evident in the following chapters, adapting forests to climate change in Valais frequently requires taking positions and making decisions that are neither straightforward nor free from contradiction.

In summary, not only my position in relation to the field but also my position within academia has shaped both the results and the dissertation as a whole. This position must likewise be

understood dialectically and relationally: my place within academia influenced this research, while the process of writing the dissertation simultaneously contributed to my intellectual and personal development.

A final issue that has become increasingly relevant in contemporary academic practice is the influence of artificial intelligence (AI), particularly text-generating tools such as ChatGPT. These technologies developed rapidly during my doctoral studies, accompanied by growing debate about their appropriate use. Without taking a definitive stance in these debates, I wish to clarify how I employed such tools in this dissertation—namely, almost exclusively for revising texts I had already written.

As English is not my native language and this dissertation is written in English, I relied on language-assistance tools throughout the writing process. I often drafted sections in a mixture of German and English and used the DeepL translation software to translate German passages. I then carefully reviewed and revised these translations and occasionally translated English passages back into German to check for shifts in meaning.

Subsequently, I submitted sections individually to ChatGPT (latest Version 5.2) using prompts such as "Please check the following chapter of an academic work for spelling, grammar and style." For reasons of data protection, I did not input any unpublished material (e.g., interview excerpts). After receiving feedback, I reviewed and revised the texts—often through multiple iterations—to ensure that they reflected my intended meaning. At times, I observed that AI tools tended to shorten or omit passages in which I articulated novel ideas, such as the concept of the possible. Unsurprisingly, the tool could not readily assist in formulating concepts that lack established representation in the literature. Sections grounded in highly personal reflection—such as the positionality discussions—also proved less amenable to automated revision.

Where AI proved particularly valuable was in supporting the act of writing itself: it allowed me to express ideas freely without immediately focusing on grammar, clarity, or stylistic conventions, knowing that refinement could follow. It is important to emphasise that I did not use AI for content generation but solely for revision and translation—understood broadly to include the conceptual translation between academic registers and styles.

My engagement with AI was dialogical and thus consistent with the dialectical orientation of this dissertation. I used these tools as conversational partners (see Carrigan, 2025), occasionally extending beyond editing—for example, when requesting alternative phrasings or suggestions for section titles. Nevertheless, I retained both the first and the final word in this dialogue and stand fully behind everything written in this thesis.

5.4 Summary of the research interest

Having described the case study, the empirical and analytical methods, and my positionality, I now return to the research questions developed in Section 4.3.2 and explain how I intend to address them using the data collected. The fundamental question underlying this study is: **How does the possible future forest emerge?**

By this point, it should be clear that this study empirically investigates the discursive act of referring to the interplay between structure and contingency that underlies the notion of the possible forest. According to the principle of referential detachment, this practical act is understood as the sublation—and thus the relation—between the referring actor and the referent. Although this discourse-analytical approach presumes that the referrer is a language-capable and therefore ultimately intentional agent, this intentionality does not necessarily apply to the referent. Ultimately, it is not the discrete entities of actor or referent that are examined individually, but rather the relationship between them.

The first sub-question investigates the perspective of the knowing actor and thus relates to biophysical nature: **(1) How is change in the forest ecosystem epistemically grasped and made tangible?** It focuses on how foresters in Valais refer to aspects of biophysical nature—particularly its novel and unknown elements, such as extreme events, the dieback of certain tree species, or the emergence of new ones—that are not yet fully articulated in language. The emphasis lies on how these natural events are explained through causal powers and how particular truth claims are epistemically evaluated through reference to the interplay between the empirical and the theoretical. Interviews with foresters provide the primary empirical basis, enriched by documents and personal observations. This research question is addressed in **Chapter 6**.

The second sub-question shifts the focus to practice: **(2) How is individual practice made possible under conditions of forest change?** Here, the normative dimension of the conceptual framework is introduced to foreground the perspective of the always-already-acting actor. The analysis examines how foresters activate their embodied powers, guided by moral intention or desire, and how they intervene in the forest ecosystem—for example, by cutting or planting trees. The reference point is therefore practice in a changing world and the possibilities and resistances that this practice encounters. This investigation builds on the same data corpus used in Chapter 6 and is addressed in **Chapter 7**.

Since every knowing and acting actor is also socially embedded, **Chapter 8** focuses on their social context. This leads to the third research question: **(3) How is the space of the possible forest simultaneously enabled and constrained through social relations?** The empirical entry point is societal contradictions and struggles—such as political debates on wildlife management and invasive species—in the context of FACC in Valais, as well as the forestry sector's search for legitimacy for its own work and, ultimately, the social order that defines and seeks to address the

problem of forest adaptation to climate change. Here, the focus shifts away from individual actors to consider foresters in relation to, and in dialogue with, other social groups (e.g., hunters, politicians, the general public). In addition to interviews, this chapter draws more extensively on published documents from institutions such as FOEN, WSL, cantonal authorities, the media, and scientific literature in order to retroduce the structural conditions foresters face in adapting forests to climate change.

Returning to the key methodological question—"Of what is this a case?" (Lund, 2014)—it is important to emphasise that this study does not represent all cases of FACC, nor even another specific case of this kind. It is therefore not representative in a statistical sense. Rather, its value lies not in its breadth but in its depth. The focus is on exploring the causal powers that shape the possible, as well as the causal power that emerges through this layer of reality. In the FACC case study in Valais, possibilities are empirically captured using the conceptual framework presented above, and conclusions are drawn abductively as to how the possible must be constituted in order for such empirical manifestations to arise. This involves retroducing how the field of possibilities in the present case is delimited by references to causal forces while simultaneously being opened up by references to contingency—so that the possible, paradoxically, becomes possible.

This research does not aim to provide immediate practical benefit or statistical generalisation within the field of FACC. Nor does it advance explicit normative claims for or about forestry in Valais, or more broadly about forest management under climate change. Instead, the aim is to explore what can be said about humans' and society's relationship to the world in the current context of ecological change and complexity, and what ultimately structures the ways in which this problem is defined and addressed.

In this sense, the present study is directed less at forestry practice than at academic debate. Its motivation is to open up new perspectives and interpretations of the problem and to contribute to a broader openness in the world. Ultimately, knowledge about the causal structures of the world is "necessary"—though "insufficient"—for change in the world and thus for freedom (Bhaskar, 1986:170). In this sense, the study contributes to change itself and, indirectly but concretely, also to forestry—both in general and in Valais.

5.5 Conclusion: Setting the stage for an empirical investigation of FACC

This chapter has complemented Chapters 3 and 4, in which I outlined the theoretical foundations and conceptual tools, by specifying the methodological approach. The preceding discussion has already established several key elements of this methodology: the concept of ontological depth enables the case study to make claims that extend beyond the immediate case and to pursue an explanatory rather than purely descriptive approach. Likewise, the concept of referential

detachment, together with the broader conceptual framework, provides the basis for an abductive analysis of empirical observations in a relational manner.

Valais, with the diverse characteristics described in Section 5.1.2, constitutes the empirical setting for this investigation. The methods of data collection outlined in Section 5.2.1 allow the case to be examined from multiple perspectives—for example, those of science and policy-making—while maintaining a primary focus on the practices of foresters. At the same time, these methods make it possible to move beyond the specific case of Valais and to situate it within the broader Swiss context, as well as within wider European and Western debates on FACC.

The following chapters therefore examine how the theoretical and conceptual framework proposed here resonates with the empirical world: how it captures this world, reveals the deeper causal powers operating within it, and enables statements both about and beyond the case itself. These chapters are structured according to the sub-questions presented in Section 5.4: Chapter 6 addresses the epistemic grasping of climate change and its influences on forests in Valais; Chapter 7 turns to normatively oriented practice as an intervention in this changing world; and Chapter 8 examines the social conditions within which these forms of knowledge and practice emerge.

Chapter 6: Grasping ecological change: Uncertainty about the future forest

As discussed in Section 5.1.2, the region of Valais presents a distinctive climatic context within Switzerland and Central Europe. It is characterised by dry, warm summers and cold winters, alongside a diversity of local microclimates shaped not only by broader macroclimatic patterns but also by topographical features typical of mountainous regions—such as altitude, slope exposure, and soil depth and composition. Biologically, the vegetation at any given site reflects the interplay between these abiotic conditions and the characteristics of species and their ecological interactions.

Over centuries, local populations have adapted to these environmental conditions. Ingenious infrastructures—such as traditional irrigation channels ("Suonen" in German or "bisses" in French)—were developed to transport meltwater from glaciers and snowfields at higher altitudes to arable land during the dry summer months. Settlements were established in locations considered relatively safe from persistent natural hazards, including avalanches, rockfalls, and debris flows. A central factor in determining such safety was the presence of forests, long understood to play a protective role in mitigating these dangers.

It can therefore be assumed that the functional mechanisms of forest ecosystems—particularly their protective capacities—were gradually learned, integrated into local knowledge systems, and transmitted across generations (Loup, 1960). However, in recent decades a long-assumed constant has begun to shift: the global climate is warming. Scientific measurements confirm that the Valais region is likewise experiencing this trend. Since the nineteenth century, average temperatures in Switzerland have increased by 2.9°C, with particularly pronounced warming in alpine regions such as Valais, where summer temperatures have risen by more than 4°C. Projections suggest an additional increase of approximately 3°C by 2060 if greenhouse gas emissions persist at current rates (National Centre for Climate Services, 2024; MeteoSwiss, 2025). As a result, the biophysical environment has already begun to change—and forests must adapt to these evolving conditions.

Against this backdrop, the chapter investigates how ecological change is epistemically apprehended and rendered tangible within forestry (see Research Question 1 in Section 4.3.2). The analysis proceeds from the perspective of actors—principally foresters—situated within this changing world. In line with the critical realist grounding of this study, knowledge is understood as always presupposing and referring to a reality beyond itself. I therefore mobilise the dialectic between the causal and the actual to examine how the biophysical world of forests is explained. Concurrently, I draw on the dialectic between the theoretical and the empirical to analyse how knowledge about this world is articulated and reflected upon. Taken together, these dimensions

illuminate the emergence of the possible forest in terms of knowledge about the biophysical world.

The structure of the chapter reflects this conceptual orientation. I begin by providing a general account of how forests as biophysical systems are apprehended in the context of climate change, drawing on both scientific perspectives and foresters' viewpoints (Section 6.1). I then explore how foresters refer to observed events in the forest and link them to causal explanations, demonstrating the difficulties involved in establishing linear causal connections (Section 6.2). Section 6.3 shifts the focus from events that have already occurred to imaginations of the future forest, examining how it is shaped by theoretical frameworks and by reflection on their limits.

Empirically, the analysis draws primarily on interviews with foresters, supplemented by discussions with other actors and insights from scientific reports. Key quotations are presented and interpreted using the abductive methodology outlined in Section 5.2.3. Each subsection concludes with a brief synthesis of interim insights, while the final part of the chapter offers a comprehensive discussion of the findings and highlights their contribution to the overarching research question.

6.1 Understanding forest change: Between certainty and uncertainty

This section outlines the general state of knowledge about forests under conditions of climate change in Valais. Particular emphasis is placed on how forests are conceived as complex, open systems in which a multiplicity of causal powers is at work. I first show how, in this context, the notion of change figures prominently in discourse about the future of these forests, highlighting that it is often invoked in abstract terms yet treated as determinate and inevitable (Section 6.1.1). I then analyse how this change is articulated in scientific reports and by a forest scientist, demonstrating how the future forest is rendered intelligible through constant conjunctions of events that are nevertheless qualified through the use of conditionals, subjunctives, and modal verbs (Section 6.1.2). Finally, Section 6.1.3 examines how foresters relate climatic change to forests, showing how both certainty and uncertainty shape their understandings.

6.1.1 The certainty of change

In an interview conducted relatively early in my fieldwork, I posed the following opening question to a scientist: "Where are we currently heading in Switzerland, especially in Valais, in terms of forests and climate change?" His response was as follows:

> Well, that's a simple question. Difficult to answer, of course. So, where are we heading? We are definitely heading towards change. If these scenarios, which we have developed and which are actually plausible, should occur, more or less extremely, then the Swiss

> forest will most certainly change dramatically (Interview "Scientist 3", September 2022).[44]

In this excerpt, the scientist emphasises the transformations that forests are expected to undergo. He presumes a causal relationship between a changing climate and the evolving appearance of forests, presenting this relationship as the driving force behind an anticipated transformation. Although he later discusses more specific developments, he initially foregrounds change at an abstract level, portraying it as something that will occur "definitely" and "dramatically."

From this scientist's perspective, change in forest ecosystems in Valais appears inevitable. Two foresters I interviewed responded in a similar manner:

> *JZ (Jan Zumoberhaus):* What will these forests here in Valais look like in, say, 50 years? […]
> *IP (Interviewed Person): [pause of several seconds]* Different! But it's difficult to say for sure what [which trees] will survive. It really depends on what it [the climate] looks like in 50 years. That's clear. We will definitely still have forests. That's for sure. But I have the feeling that these are pioneers. Short-living pioneer tree species (Interview "Forester 7(1)", February 2023).

> *JZ:* What will the forest[45] look like in 30, 40 or 50 years? […]
> *IP:* If you had asked me that 30 years ago, I would have told you. *[Laughs]*
> *JZ:* Such as?
> *IP:* More stable than it was before. More diverse. […] A healthy, stable protective forest. […] At the moment, with climate change, everything is actually called into question (Interview "Forester 5", February 2023).

At first glance, these responses are abstract and may appear somewhat evasive; Forester 7 even hesitates before answering. What stands out in both accounts, however, is not so much change itself as difference: the future forest is described primarily in terms of how it will diverge from a scenario without climate change. This distinction between *difference* and *change* can partly be attributed to the framing of my questions. The formulation "heading toward" in the question posed to the scientist invites a more processual response, whereas the foresters were asked to describe the forest's appearance at a more specific point in time. Regardless of this nuance, the emphasis of the foresters' answer falls less on the process of change and its underlying causes than on the particular events or states that the future forest may bring.

Viewed through the conceptual framework developed in Section 4.3.1, these statements constitute immediate references to the natural world and operate within the dialectic between causal powers and events. At this level of knowledge, there appears to be little doubt. This certainty is

[44] All quotations from interviews or grey literature that were not originally in English have been translated by me, with support from DeepL. Every effort has been made to preserve their meaning, even where this required non-literal translation.
[45] It is worth emphasising that, both in German and in French, the singular term "the forest" is frequently used to denote the collective entity of forests within a specific region. As will be seen in Chapter 8, the expression "the forest" is also employed to distinguish the domain of forestry from other socio-economic groups, such as hunters, risk managers, or spatial planners.

further reinforced by specific linguistic markers: Forester 7 uses expressions such as "That's clear," "That's for sure," and "definitely," all of which signal strong conviction. Yet when more concrete differences are addressed, he shifts to the phrase "I have the feeling," thereby introducing an element of uncertainty. In doing so, the forester draws on the theory of succession to explain the future state of the forest while simultaneously expressing doubt as to whether this theoretical model will align with the empirical realities that may eventually unfold (see also Section 6.3).

A similar element of uncertainty emerges in the scientist's reference to scenarios. Although he regards them as "plausible," the anticipated dramatic changes in forests remain conditional upon whether these scenarios actually occur (I return to the centrality of such *if*-clauses in the following sections).

Forester 5 articulates this uncertainty even more explicitly by noting that he could have provided a clear and confident answer to the same question thirty years ago—but no longer can. He thus underscores the limits of predictive knowledge regarding the concrete forest of the future. What appears certain to all three actors, then, is change itself at an abstract level, while the concrete expressions of this change in the form of observable events remain uncertain.

What is certain, however, is not only the occurrence of change but also its speed, as underscored by Forester 7:

> The change will come automatically. But it's happening way too fast. This is my opinion. […] Because of the heat, it [the forest] may no longer be able to keep up. That's for sure. […] There will definitely be a significant change (Interview "Forester 7(1)", February 2023).

Thus, despite the softening qualifier "This is my opinion," the forester conveys certainty not only that change will occur but that it will unfold too rapidly. This invocation of temporality arises from a perceived imbalance: rising temperatures are understood to outpace the forest's capacity to adapt. Within this struggle between causal forces, the abiotic factor of heat is seen as taking precedence, ultimately overriding the forest's organic processes. This interpretation highlights the dependence of biotic elements on their physical conditions.

Changes and differences in the forest are therefore framed as inevitable within the context of climate change, yet they remain abstract in nature. By contrast, the concrete manifestations of these transformations in forest appearance remain uncertain. In this sense, the emergence of uncertainty depends upon the presence of something regarded as certain: the climate is changing, and forests are struggling to keep pace.

Importantly, the uncertainty illustrated in these accounts does not merely signal a lack or absence of knowledge. Rather, it reflects a tension between established knowledge of causal processes in the natural world and uncertainty about the completeness and adequacy of that knowledge under conditions of climate change. Two forms of knowing thus come into view: one directed toward the

external world of nature and its causal dynamics, and another reflexively oriented toward knowledge itself and its limits. Although analytically distinguishable, both are essential for grasping the possible forest of the future. Their interplay is explored further in the following sections.

6.1.2 Constant conjunctions of events? Scientific accounts of forest change

Given this certainty of change, I now examine how the future under altered climatic conditions is imagined in terms of concrete events—that is, through which analytical moves it is rendered intelligible. I begin by focusing on scientific projections of the future of Valais forests before turning, in the following section, to foresters' accounts.

In a report commissioned by the cantonal government and published in 2016, *Valais in the Face of Climate Change*, which summarises the scientific foundations of climate change, the effects on forests are described as follows:

> Very dry conditions and high temperatures make vegetation in low-lying areas of central Valais sensitive to the effects of climate change (death of Scots pine in dry locations below 1,200 metres above sea level). In higher altitudes, however, rising temperatures have a positive effect on forest development (faster growth, spread of Swiss stone pine and spruce).
> In the medium term, the Valais forests at high altitudes will benefit from climate change, with an increase in biomass and denser forests. However, denser forests are more susceptible to forest fires, bark beetle infestation, windthrow and snow breakage. [...]
> In the long term, if precipitation continues to decline in the summer months and longer dry periods become more frequent, site conditions for most native tree species will deteriorate significantly and biomass will decline (Nauser, 2016:7).

From a scientific standpoint, this passage presents a relatively coherent and linear account of the future state of the forest. Scots pine (*Pinus sylvestris*), currently dominant at lower altitudes, is expected to decline; at higher elevations, species such as Swiss stone pine (*Pinus cembra*) and spruce (*Picea abies*) are predicted to expand; and overall biomass is expected to increase initially before eventually declining. What is described here is the outcome of causal relationships between global climate change, shifts in local abiotic conditions (such as increased drought and heat), and the biological characteristics of specific tree species.

Importantly, these causal relationships in nature are not articulated directly but rather through descriptions of recurring patterns of events. In other words, the focus lies on what the forest is likely to look like at particular future moments. Here, the dialectical interplay between causality and events in describing biophysical change becomes apparent in the form of an assumed regularity and stability of these events over time. In critical realist terms, such a conception of the future forest rests on the presupposition of a constant conjunction of events: causality appears to operate linearly at the level of events, which in turn appear determined. In this regard, complexity and heterogeneity of outcomes—and accordingly a field of possibilities—remain concealed.

Yet this seemingly straightforward depiction of the future is complicated by several elements that introduce ambiguity and uncertainty. Time, for instance, plays a central role. While the events described—such as tree mortality—are clearly constrained by spatial and temporal conditions, the report itself remains vague. It does not specify concrete timeframes but instead relies on imprecise temporal categories such as "medium term" and "long term." Although these categories offer some orientation, they remain analytically underdetermined.

A subtle yet important normative dimension is also embedded in the language. Terms such as "positive" and "benefit" are not used in an explicitly moral or social sense; nevertheless, their presence implies that increased tree growth, greater biomass, and the expansion of certain species are considered desirable—at least from a forestry or management perspective. This implicit normative framing warrants closer examination, to which I return in detail in Chapter 7.

Furthermore, the passage contains a key element referring to what I have conceptualised as the realm of the possible. The seemingly minor word "if" signals that the projected outcomes depend on specific conditions being met—in this case, a continued decline in summer precipitation and an increase in dry periods. While the underlying causal relationship between these conditions and the deterioration of site conditions or biomass decline is taken as given, its actual activation remains uncertain. Thus, even within the assertive framing of this scientific report, uncertainty is acknowledged.

A similar mode of reasoning appears in a 2015 report summarising the state of scientific knowledge on forests and climate change in Valais, authored by a cantonal forestry engineer:

> Frost periods are becoming shorter and less intense. In addition, the snow cover is melting faster. The ground is exposed faster and warms up more quickly. In short, a milder climate will lengthen the growing season, which will favour the advance of non-native plants. If this trend continues, the forest may gradually advance to higher altitudes. This will be a very slow process, as trees encounter adverse climatic conditions in the mountains, which is why the tree line is often referred to as a "battle zone". On the sunny and dry slopes (southern slopes of Valais) at lower altitudes, however, the forest could retreat in favour of steppe, as the drought stress for shrubs and trees will become too great. Only a few particularly resistant shrubs and bushes could survive there [...] (Métral, 2015:6).

Here again, the effects of climate change on forest ecosystems are framed in terms of a constant conjunction of events: longer growing seasons, upward forest expansion, and retreat at lower elevations are expected to occur. However, a field of possibilities is even more prominent than in the previous excerpt. The conditional "if" introduces a projection of how trees and forests might respond to changing climatic conditions. As before, this if-clause simultaneously invokes causality, possibility, and uncertainty, bringing these elements together.

Moreover, the use of modal verbs such as "may" and "could" further underscores that the future is not predetermined but open. These expressions point to a double contingency: first, the

occurrence of the condition itself is uncertain; second, even if the condition is met, the anticipated outcome remains only one among several possible outcomes.

Such references to the possible—and thus to uncertainty—become even more explicit in interviews with forest scientists than in written reports. This is evident in the following excerpts from an interview with a researcher on the effects of climate change in Switzerland:

> So if we look at individual tree species and imagine a climate envelope, beech stands in the centre of the envelope will still be beech stands, but today they are perhaps moderate beech stands, whereas in the future they will be dry beech stands. However, the dry beech stands of today will shift towards oak forests, for example. That's why we can see that changes will not only occur in Valais [...] but almost everywhere. However, there will not be new tree species compositions everywhere (Interview "Scientist 3", September 2022).

> What we have seen in recent years is that less and less water is actually entering the system. Precipitation has remained fairly constant, with high annual variability. But it is not the case that it is much drier today. What we do have, however, is significant warming, which leads to an increase in evapotranspiration, meaning that there is less water available in the soil. [...] And if the sites are still shallow, then it may well be that drought stress increases massively there (Interview "Scientist 3", September 2022).

In the first excerpt, the researcher explains the concept of a "climate envelope," which describes the ecological niche of a species based on its tolerance to temperature and precipitation. A species such as beech (*Fagus sylvatica*)[46] can thrive within a specific range of these variables, but not beyond them. Its current distribution is therefore bounded by climatic thresholds, indicating a causal relationship between climatic conditions and species occurrence.

However, the niche theory invoked here is not deterministic: even when climatic conditions fall within the appropriate range, a species may fail to establish itself—for example, due to unsuitable soil conditions or competition from other species. The theory thus allows for causal explanation without guaranteeing outcomes.

This absence of determinism is evident in the researcher's observation that variability within niche parameters does not imply the immediate disappearance of beech from all current sites, nor its straightforward replacement by more drought-tolerant species such as oaks (primarily *Quercus pubescens*). Species persistence or disappearance is therefore neither linear nor homogeneous.

In the second excerpt, nonlinearity and complexity become even more apparent. Drought stress, for instance, does not result solely from reduced annual precipitation. Higher temperatures accelerate soil moisture loss, and under the additional condition—again introduced by an if-

[46] It is important to note that beech is largely absent from the central and upper parts of Valais. However, as one of the most common tree species in Switzerland, it often serves as an illustrative example, as in this quote.

clause—of shallow soil depth, this may lead to drought stress. Here, the causal mechanism is not one-dimensional but unfolds through the interaction of multiple factors.

What emerges is a picture of the forest ecosystem as too complex for any single explanation or forecast to fully capture. Consequently, any apparent constant conjunction of events is accompanied by linguistic expressions that qualify it. This language is evident not only in conditionals, subjunctives, and modal verbs such as "can," "may," and "could," but also in rhetorical markers such as the repeated use of "but," particularly in the interview excerpts. The function of "but" is to qualify, revise, and restrain claims—an indication of the limits of language in representing the full dynamics of biophysical processes.

At the same time, it is important to note that attempts are made to articulate change in ways that provide a relatively coherent picture of the future—for example, through references to constant conjunctions of events or the application of niche theory. Not everything appears contingent; a systemic and structured account of ongoing environmental change remains possible.

6.1.3 Uncertain explanations: How foresters interpret climate change

In the previous sections, knowledge about the future forest under climate change in Valais was described as following a seemingly homogeneous pattern: while change is regarded as certain, structured accounts of the future forest remain infused with elements of contingency and uncertainty. This section offers a more nuanced picture of how foresters—who must engage with the future in their everyday practice—grasp this complexity by explaining the influence of abiotic (climatic) causal powers on biotic elements such as trees and how these relations translate into particular events.

In an interview conducted in February 2023, a forester responded to my question, "What do you currently see in the forest?" as follows:

> You have climate change, which is obviously happening. […] That can't be explained away. You have the precipitation, which is decreasing. And the temperature, which is higher. That causes a lot more stress for the forest. It's clear. We have warmth much earlier, last year too. Now in February it's already 15 degrees. That's crazy! (Interview "Forester 7(1)", February 2023).

Here, two general patterns of actual events—decreasing precipitation and rising temperatures—are causally linked to, and explained by, climate change. Climate change is invoked as activating causal powers that produce these events, which otherwise would not occur. Furthermore, the forester highlights a concrete spatio-temporally situated event—15 degrees Celsius in February 2023 in Valais—and relates it, at least implicitly, to climate change.

This particular event clearly holds significant meaning for the forester. The very fact that it is mentioned in an interview, accompanied by the exclamation "That's crazy!", underscores its extraordinariness. Yet this extraordinariness does not reside in the isolated event alone, but in how the

event is analytically connected to earlier occurrences (such as unusual warmth in the preceding year) and ultimately to climate change—something that remains empirically invisible as such, or only visible through its consequences. Here, the epistemological dialectic conceptualised in Section 4.3.1 becomes evident: immediate empirical experience is connected to prior knowledge—past observations and the theoretical model of climate change—in order to emphasise its significance.

Notably, in this quote the forester does not elaborate on the implications of such climatic conditions for the forest itself. This becomes more apparent in another interview conducted in March 2023:

> We just had a very hot summer, and a mild winter [...]. Now [in early spring] we're getting this rain. So much the better, but it needs to come more, more, more. But if, all of a sudden, we have a dry spring and then we go into to a dry summer again, [then] I have no idea how it [the forest] will react. I have no idea how it will react. I think we'll have problems there. But that's the climate (Interview "Forester 8", March 2023).

At first glance, this forester appears to draw a linear connection between climate change and observed weather events. Upon closer inspection, however, what stands out—compared to the previous account—is the presence of indeterminate elements. The forester connects current weather conditions to a possible future outcome through an if-clause: if the year continues to be warm and dry, problems will arise in the forest. This conditional construction expresses a potential causal relationship within the biophysical world—one that has not yet been actualised and will only do so if the condition itself becomes true. Whether the year continues to be dry therefore remains undecided; both scenarios are possible within the biophysical world to which the forester refers.

At the same time, this statement includes a reference to knowledge about these processes. Under the assumption that dry conditions persist, the forester admits to having "no idea" how the forest will respond. What is certain, then, is the absence of knowledge—the forester recognises the limits of his understanding of the natural world. Here, the field of possibilities opens primarily in reference to a natural world that transcends knowledge, rendering the knower comparatively insignificant. This is further reinforced by the remark "But that's the climate," which suggests that climate itself exceeds the grasp of any individual observer.

From a climatological perspective, however, a dry spring or summer would not typically be classified as "climate," since climate is defined over much longer temporal scales. Climatologists are therefore often cautious about attributing single weather events directly to climate change. This caution is echoed by another forester, who responded to my question about whether he observed the effects of drought in the forest as follows:

> I don't know if it [the drought] is because of climate change. It is just dry. There are dry summers. There always have been. It makes sense that if there is global warming, then

> the stuff [the trees] goes higher […]. That's clear to me (Interview "Forester 6", February 2023).

This was the only interview in which a participant did not identify climate change as a central issue for forests. While he did not explicitly deny its existence, he framed climate change as a discourse instrumentalised by government and other actors to legitimise interventions in forest management ("That's how politics works these days, fearmongering from morning till night").[47]

This quote is nonetheless instructive, as it demonstrates that empirically observed events—such as dryness—are not necessarily interpreted through the lens of climate change theory.

The forester refers to dryness strictly at the level of the actual event: "It is just dry," implying no causal connection beyond the observed condition itself. This contrasts with the earlier interview with Forester 8, who speculated about future weather events. The key distinction lies in the temporality of their claims. While Forester 8 anticipated future developments, Forester 6 commented on the causal significance of an already occurred—and thus caused—event: the drought.

Importantly, he does not deny that it was dry. For him, the drought is certain—it happened. What he questions is not the occurrence of the event, but its cause. This moment arises from a reference to his own knowledge: he "does not know" whether climate change caused the drought, implying that both explanations remain possible.

Yet immediately following this dismissal, the forester introduces a conditional causal link: if global warming exists (a proposition he neither affirms nor rejects), then "the stuff [the trees] goes higher." The knowledge underlying this causal connection appears certain to him: "It makes sense," "That's clear to me." Here, uncertainty and a field of possibilities re-emerge, but now in relation to the future biophysical world. The statement that trees migrate upward with climate change refers to a causal process—albeit one articulated through the conditional "if there is global warming."

To be clear, the aim of this discussion is not to cast doubt on the existence of climate change; my own position has been articulated throughout this thesis. Rather, the goal is to show that climate change and events already experienced by individuals remain open to multiple interpretations. It is precisely within this interplay—between references to the natural world and reflections on one's own knowledge—that openness, and thus uncertainty, emerges. Both moments are always at play, jointly opening a field of possibilities.

[47] Only one of the eleven foresters interviewed expressed climate-sceptical views. This observation should not be generalised to the broader population of foresters in Valais, as the sampling strategy likely introduced selection bias. Potential interviewees were contacted via email with an explicit reference to "forests and climate change," which may have reduced participation among individuals less engaged with or sceptical of the topic.

Taken together, these accounts demonstrate that foresters articulate change in the forest through a combination of certainty and uncertainty—not only with regard to the biophysical characteristics of the forest itself, but also to knowledge about it. Alongside moments of openness and indeterminacy, structured expectations and relatively stable causal assumptions persist concerning how forests respond to climatic change. The future development of forests is therefore understood as neither radically unknowable nor fully determined. Rather, uncertainty and certainty, openness and causal determination coexist and can be retraced relationally within foresters' grasp of the future forest.

In this section (6.1), I have shown that the central themes of this study—environmental change and the associated emergence of uncertainty and the layer of the possible—play a significant role in the case examined here. Change is frequently described in abstract terms and, paradoxically, emerges as the only certainty. Scientific syntheses of futures under climate change often seek to establish clear and linear causal narratives; yet such accounts are invariably mediated by conditionals, subjunctives, and modal verbs that point to possibilities rather than determinate outcomes.

References to the field of the possible become even more pronounced in foresters' accounts of the future forest, where attention is directed both to multiple potential states of the biophysical system and to the limits of knowledge about it. At the same time, relatively enduring elements persist across these accounts—notably the assumption that climatic change entails transformation in forest ecosystems and the acknowledged presence of uncertainty itself. Taken together, these observations suggest that forests are conceived, on the one hand, as open systems, while, on the other, explanatory or predictive knowledge about them remains inherently limited.

6.2 Tracing causal links to climate change

Having provided a general account of how change in forest ecosystems is grasped in the context of FACC in Valais, I now turn to how foresters refer to events they have directly experienced and how they connect these to global warming. Section 6.2.1 examines concrete cases of tree dieback linked to meteorological extreme events; Section 6.2.2 focuses on gradual dieback; and Section 6.2.3 considers the bark beetle as an element of latent causality.

6.2.1 Extreme events and tree dieback

Climate change is perhaps most tangible in so-called extreme events—events that deviate markedly from the norm. However, the exceptional nature of such events, as well as their causal connection to climate change, is not immediately self-evident and must instead be analytically inferred. This section therefore explores how foresters in Valais establish this analytical link.

Commonly cited examples of extreme events affecting forest ecosystems in Valais include major storms such as Vivian (February 1990), Lothar (December 1999), and Vaia (October 2018), as well as large-scale forest fires such as those in Leuk (2003) and Visp (2011).[48] However, during most of my interviews with foresters (conducted between autumn 2022 and spring 2023), the summer drought of 2022 emerged as the dominant topic of discussion:

> As is well known, we are experiencing a very severe drought. Extremely severe. And now, when we go into the pine forests, we can clearly see the effects: the pine trees are beginning to die en masse. We have been seeing this for about a week now. I had a feeling this was coming, but… We've had similar phenomena several times before. I've been here [as a forester] for over 30 years now. But this is a bit more than I've ever seen (Interview "Forester 3", September 2022).

In this case, the dieback of Scots pine (*Pinus sylvestris*) is attributed to drought—or, more precisely, this causal relationship is inferred from the simultaneous occurrence of these two events. The quote also illustrates how the event of tree dieback is empirically registered: while the drought is described as "well known" (German: *bekanntlicherweise*) and thus requires no further explanation or empirical evidence, "you can *see* the reactions" in the pine trees. Direct empirical experience therefore enables the forester to infer a causal relationship.

An observation I made during an interview with Forester 9 in March 2023 further underscores the importance of direct empirical experience. When I asked whether he had observed any changes, he stood up, opened the office window, pointed to a group of pine trees, and said: "I've never seen that before."

The phenomenon referred to—though not explicitly stated in these quotes—is the browning of Scots pine needles, which normally remain green throughout the year (see Figure 9, p. 119). This makes it a clearly visible and easily identifiable event. Images of brown pine trees (or other species) therefore frequently appear as visual icons in publications and webpages addressing forests and climate change in Valais (see Figure 10, p. 119). Their visibility provides a perceptible link to the otherwise abstract phenomenon of climate change.

Moreover, the quotes emphasise the exceptional character of this phenomenon—Forester 3 had never observed anything comparable in 30 years, and Forester 9 likewise drew on decades of experience—thereby underscoring the subjective dimension through which significance is

[48] A large-scale forest fire also occurred above Brig in July 2023, which could in principle have served as a detailed case study. I chose not to pursue it further, however, as the event was highly limited in both its temporal and spatial extent. According to media reports, the immediate cause was identified as a short circuit in a power cable. While the fire received extensive public and media attention, it primarily sparked broader debate about whether forest fires are likely to become more frequent under climate change. Experts consistently emphasise, however, that both the frequency and intensity of forest fires depend on a range of interacting factors beyond climate change alone, including forest management practices, individual human behaviour, and the availability of combustible material (see, for example, Pezzatti et al., 2025). A comprehensive analysis of the causal relationship between climate change and forest fire dynamics would therefore require a dedicated study and cannot be addressed in sufficient depth here.

attributed to such observations. A younger forester, or someone without a forestry background, might not assign the same importance to this phenomenon.

Yet the causal relationship between drought and needle discolouration must first be analytically established. This inference appears logical within the widely accepted theoretical premise that trees, as living organisms, require water to survive and begin to shed needles when water becomes scarce.

In addition to such analytical reasoning (which exists primarily at the theoretical level rather than in purely empirical form), correlations in the form of event regularities can serve as useful heuristics for identifying causal links. Consider the following quote from the forester who earlier described the February temperature of 15 degrees as “crazy”:

> We have a huge mortality rate. If you look at what's happening now, it’s crazy. […] There have already been several rounds of mortality. There was one in 2003. There were others before that. But after that, it was really extreme in 2018. And now again last year [2022]. And this year will be exactly the same. If this [high temperature] continues, this year [2023] will be even drier than last year (Interview “Forester 7(1)”, February 2023).

It is widely recognised in Switzerland—and supported by meteorological data—that the summers of 2003, 2018, and 2022 were exceptionally hot and dry. It is therefore understandable that a correlation between heat and tree mortality might lead to an inference of causality, even if this reasoning is not deductively conclusive.

More revealing, however, is how such causal interpretations of past experience are mobilised to project future developments: if unusually warm temperatures persist into the summer, trees will die again. This conclusion rests on two components: an established causal relationship (trees die under prolonged dry conditions) and an as-yet-undetermined condition (whether the summer will indeed be dry). I return to this future-oriented deployment of causal reasoning in Section 6.3.

Beyond such correlations, causal mechanisms linking drought to tree responses are also interpreted through existing biological knowledge:

> I don’t know how things will continue. If we have years like 2022, which was so dry and hot… If 2023 will be anything like that, our forests will be under extreme stress again. Last autumn, we had a severe outbreak of spruce needle blight. Normally, spruce trees keep their needles for seven years. Last year, in October, they lost at least three or four years’ worth of needles. This is probably also a kind of protective mechanism. If it has fewer needles, it has less surface area to evaporate. Yes, these are the kinds of things where you just… We have become a little more sensitive and have also taken the necessary measures. I have the feeling that if the heat continues like this, our forests will effectively have an existential problem (Interview “Forester 4”, February 2023).

Spruce needle cast is caused by a fungus typically present on spruce trees without producing visible symptoms. Under stress—such as drought—however, the fungus can trigger premature needle loss. Assuming the forester is familiar with this biological mechanism, it appears

reasonable that he would interpret needle discolouration observed in October as a delayed response to the heat and dryness of the preceding summer. Yet the interpretation in this quote goes further: needle loss is described as an active response by the tree to reduce water loss. Here, the fungus is not portrayed as an adversary but as participating in a form of symbiotic relationship.

The quote also highlights the forester's reflexive engagement as both an experiencing and knowing subject: "We have become sensitive," "I have the feeling," "probably." These claims are not presented as definitive truths; rather, the forester explicitly acknowledges the subjectivity and fallibility of his knowledge. This reflexivity introduces uncertainty by relativising both the observer's position and the conclusions drawn from it. Accordingly, the field of possibilities invoked here encompasses not only a natural dimension (what might occur if the heat persists) but also an epistemological one (the possibility that existing knowledge about these causal mechanisms may be incomplete or flawed).

Nevertheless, in cases of clearly defined meteorological extremes, the foresters cited here appear able to establish relatively structured causal links between weather events and forest responses—particularly given that scientific studies reach similar conclusions regarding pine dieback and summer droughts (see especially Bigler et al., 2006; Hunziker et al., 2022).[49] At the same time, this causal framing—and the corresponding conception of the future possible—shapes the meaning attributed to, and the attention directed toward, specific empirical observations such as the browning of pine needles. It is precisely this understanding that renders foresters "sensitive" to these phenomena, prompting them to stand up and point to their manifestations.

[49] Hunziker et al. (2022) emphasise that summers characterised by low precipitation have not become significantly more frequent or more extreme in recent decades. According to their analysis, the primary driver of increased tree stress in Valais lies less in reduced rainfall than in higher air temperatures and an increased number of sunshine hours associated with climate change. These conditions accelerate soil drying and intensify physiological stress through increased photosynthetic activity, ultimately contributing to tree dieback. This finding once again highlights the complex interaction of multiple causal forces and the absence of simple linear explanations in the context of forests and climate change.

Figure 9: Discolouration of Scots pine needles, likely caused by drought (Source: Photograph by the author, Val d'Anniviers, 3 February 2025).

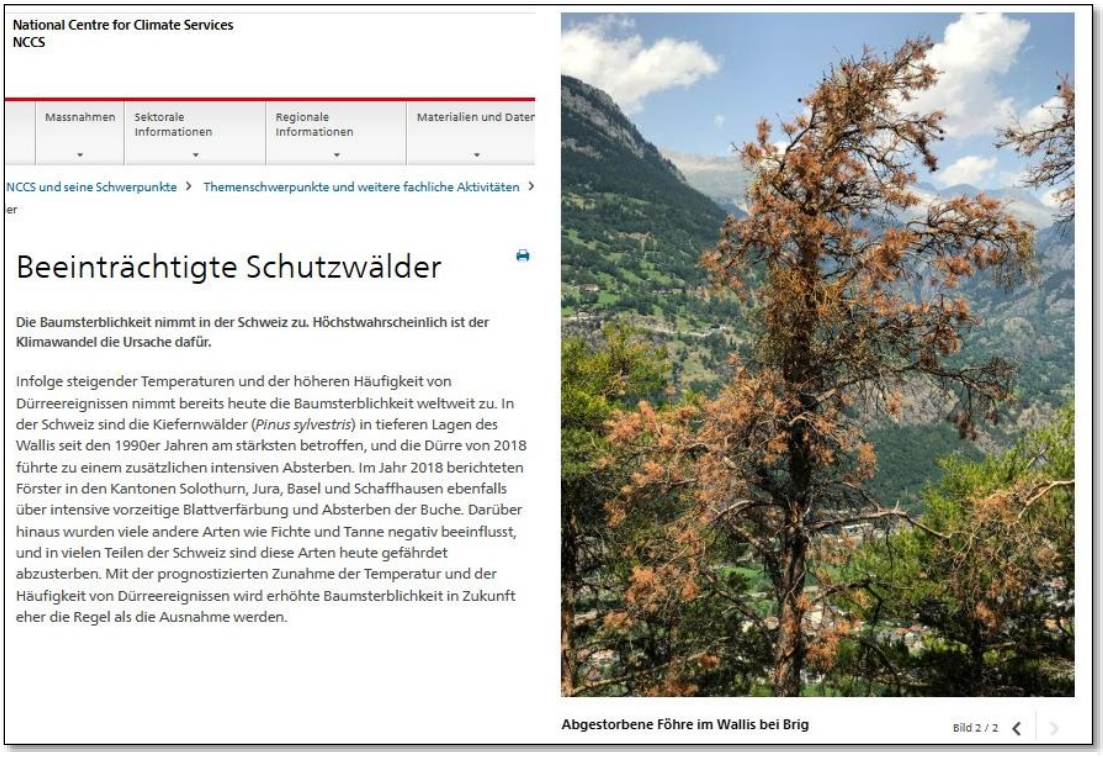


Figure 10: Discoloured pine trees in Valais as a visual symbol of climate-related forest dieback (webpage by Schweizerische Eidgenossenschaft, [no date]b, modified by the author).

6.2.2 Gradual tree dieback

In the previous section, I showed how relatively concrete, empirically observed events are linked to causal powers within the forest ecosystem. However, as the term suggests, such extreme events are temporally bounded. I therefore now turn to an analysis of how references are made to longer-term processes unfolding in nature. This temporal dimension is perhaps best illustrated by the following extended quote on pine dieback:

> The first changes—in my opinion, at least—were already noticeable in the mid-1980s. I can say that with hindsight. Back then, we were talking about beetle problems. About pine tree dieback. Pine is a type of conifer that grows in the driest locations. The pine has practically disappeared here on the south side, as you can see. Looking at it now, I can see that it was almost a precursor to what is happening now. Now the pine has disappeared. It's not disappearing completely—it may survive in better locations. But in the extreme locations, it is gone. The downy oak is coming in, the deciduous tree. Naturally. This process has been going on from the mid-1980s to now, almost the mid-2020s, so 40 years. […] So I can say that there used to be a closed pine forest here—on the south side up to 1,200 metres. […] Practically speaking, very few pine trees are remaining. That's why I say that this was a harbinger for me. Now the same thing is happening with the larch and spruce trees. […] You can see that the spruce trees are struggling. And the larch trees too. Up to an altitude of about 1000 metres. The mortality rate is very high. Higher every year. That's what we're seeing. In practice, we are noticing this dryness. It is very dry. So now, in winter, the trees are dying. Right now, on my way to work, I can see pine trees dying over the winter. Not in summer, but over the winter! (Interview "Forester 5", February 2023).

Here, the forester primarily refers to observable phenomena that have developed over several decades: the disappearance of pine trees, the regrowth of deciduous species, persistent dryness, the ongoing dieback of spruce (*Picea abies*) and larch (*Larix decidua*), forest thinning, and the emergence of young trees. The causality underlying these processes is only implicitly articulated. While it is not directly claimed that dryness causes tree mortality, the co-reference to both phenomena strongly suggests such a relationship.

Temporality plays a crucial role in this account. From his present vantage point, the forester observes pine dieback over the past forty years and relates it to the ongoing decline of spruce and larch. On this basis, a conditional causal projection appears plausible: if drought continues in the coming years, further dieback is likely to follow.

Yet such extrapolation into the future is not always straightforward:

> What we are observing here is that [the larches] are also struggling. They were less vigorous. Not at higher altitudes, but rather at 1200-1300 metres and below. You could already see that they were turning slightly yellow in the middle of summer. They were showing signs of stress. I mean, we don't know for sure. Maybe in five or ten years, if this continues, they will also be blown away (Interview "Forester 10", October 2023).

In this case, the forester interprets the observed discolouration of larch needles as a sign of stress—drought was also mentioned in the interview—but does not yet attribute major

significance to this isolated event. Only if this drought-induced stress persists might the trees become more susceptible to windthrow. Multiple layers of uncertainty and possibility thus emerge: the severity of the stress is not fully known, and it remains uncertain whether the trees will indeed fall, even if conditions remain unchanged.

Once again, temporality plays a central role in shaping this field of possibilities, as it arises from linking a present observation to a projected future. Importantly, this connection does not result from a simple linear extrapolation. Rather, the forester relativises his own observation and reflects on its meaning within a broader context. This does not imply that he considers the observation insignificant—the very act of mentioning it contradicts such an interpretation. Instead, its significance lies in what it could indicate: future events that are not yet actual but potentially more severe.

Such reflexivity in the emergence and interpretation of the possible becomes even clearer in the following quote:

> This year [mortality] was slightly lower because the hydrology was quite good. But that's just a momentary snapshot. The forest can't recover quickly. You can see that the trees have produced quite good needles and actually look quite healthy. […] But the core problem hasn't been solved in that sense. And the damage that has been done as a result of all the stressful situations can't be repaired in a year. Because there may be things that we don't even know about yet that have been destroyed here. […] But that's logical: mortality is part of nature. It's just a question of how much there is. And we are in the midst of a change where this stuff is actually disappearing. […] The additional problem is all the damage caused by insects, fungi and so on. Because all of that is increasing. And then you also have thunderstorms and hail and stuff like that. That's also a factor. And of course, it all adds up. Somewhere, the trees are under increasing stress. And then there's the tendency for hot days to increase. You have more and more days above 30 degrees. That puts more and more stress on the trees, of course. Then you have vitality, which is steadily declining, that's clear. And at some point, things tip over and then they die. This tipping point always occurs in the years when it is probably the hottest. At some point, it's over. And then they're dead (Interview "Forester 7(2)", October 2024).

This statement is likewise grounded in empirical observation—specifically, that rainfall was sufficient in 2024 and that the trees appear healthy. However, the forester immediately qualifies this assessment by shifting to a longer temporal horizon: a single year of reduced stress does not imply that long-term damage has been reversed. Additional stress factors remain at work. From the forester's perspective, it is therefore "logical" that the trees will eventually die—and once they are dead, there is no turning back.

Unlike in the previous example, current observations here do not function as immediate indicators of more severe future developments. Yet paradoxically, they remain connected to them. The forester explicitly reflects on the limited validity of his observations—"this is only a momentary snapshot"—and acknowledges that the full extent of the dieback is "perhaps," that is, possibly, not yet known. This points toward phenomena that may not have been empirically registered. In

this instance, a field of possibilities emerges primarily at the epistemological level, arising from the tension between temporally bounded observations and theoretical knowledge of long-term ecological processes.

These long-term processes themselves are not understood as contingent. The forester expresses certainty that trees will die and that "we are in the midst of a change." What remains open and uncertain is the extent—and, in this sense, the pace—of that change. This resonates with the insights from Section 6.1.1: across extended temporal horizons spanning both past and future, change is treated as inevitable, whereas its concrete spatial and temporal manifestations—whether in the immediate present or at a specific future moment—remain contingent and open to interpretation.

6.2.3 The latent causal power of bark beetles

In addition to the phenomenon of tree dieback—previously examined primarily through the interaction between drought and tree mortality—biotic pests introduce another layer of complexity to forest dynamics. Interviewees mentioned fungal diseases such as ash dieback (*Hymenoscyphus fraxineus*) and spruce needle blight (*Lophodermium piceae*), as well as insect pests including the larch moth (*Coleophora laricella*) and the pine processionary (*Thaumetopoea pityocampa*). Among these, however, the bark beetle emerged as the most frequently discussed pest.[50]

Trees and forest stands already weakened by stressors such as drought or storm damage are particularly vulnerable to bark beetle infestation, as well as to other pests. Such stressed or dying trees provide favourable conditions for beetle reproduction, enabling populations to increase and, in turn, attack healthier trees. Bark beetles thus do not act in isolation but amplify existing vulnerabilities within the forest ecosystem.

From a forestry perspective, it is therefore crucial to identify the conditions that enable bark beetle activity as early as possible, in order to intervene—typically by removing infested trees—before outbreaks escalate. In the following quote, Forester 7 refers to such enabling conditions:

> They always say that when the brimstone butterfly flies, the bark beetle flies. I saw the brimstone butterfly eight days ago. But not here [in the lower-lying area]—in the Lötschental [a higher-lying mountain valley]! It's crazy! (Interview "Forester 7(1)", February 2023).

Here, the forester describes the conditions under which bark beetles become active—specifically, when they emerge to fly and reproduce. Strikingly, this assessment is derived not from direct observation of bark beetles themselves, but from the appearance of an entirely different insect:

[50] Biologically, the term "bark beetle" refers to a large group comprising several thousand species. In the interviews, however, "bark beetle"—or simply "beetle"—was typically used in a general sense, most likely referring to the European spruce bark beetle (*Ips typographus*), the species most commonly associated with forest damage in Central Europe.

the brimstone butterfly (*Gonepteryx rhamni*). There is, of course, no direct causal relationship between butterflies and bark beetles in the sense that the former trigger the latter's activity. Rather, both phenomena are caused by the same underlying mechanism: unusually warm spring temperatures.

This example highlights once again the importance of empirical visibility in identifying environmental change. The brimstone butterfly is a conspicuous, brightly yellow coloured insect, whereas bark beetles are small, inconspicuous, and typically hidden beneath tree bark. The abnormal timing of butterfly activity—described by the forester as "crazy" when observed in a high alpine valley in February—serves as a visible indicator of anomalous temperatures. From this observation, the forester infers a causal chain linking early warmth to bark beetle activity and, ultimately, to forest vulnerability.

However, the causal dynamics of bark beetle infestations are not always so readily traceable, as another forester explains:

> We had fewer beetle nests this year than last year or the year before. The year before last was almost the worst. So the beetle nests you see now are mostly from 2021. This year there were definitely a few, but not as bad. So for me, it's not always clear why there are more now. Perhaps there are other interactions at play here that cause the trees to die later on (Interview "Forester 10", October 2023).

This statement emerged in the context of a discussion about recent droughts, particularly that of 2022. The forester recounts encountering beetle nests at times and in places that resist straightforward explanation. This uncertainty becomes more intelligible when viewed against the climatic variability of the preceding years: while 2018, 2022, and 2023 were exceptionally hot and dry, other years—such as 2021—were unusually wet. This irregular sequence does not align neatly with expectations of beetle dynamics driven solely by drought and heat, leading the forester to conclude that additional causal factors must be involved.

A third forester similarly attempts to disentangle the interplay between bark beetle damage, weather-induced stress, and other ecological variables:

> We had extensive forest damage in 2020. In 2017 and 2018, we had wet snowfall in the spring. Many spruce trees fell over. At the end of October 2018, storm Vaia came. Then, in the summer of 2020, there was huge bark beetle damage. We had a total of 675 beetle nests. […] So in 2020, we left everything standing; we didn't make use of these dry trees because we were simply too slow. It happened very quickly. Within two to three weeks, you could see them red, and then you couldn't get them out. It wasn't due to financial or staff issues. It just happened too quickly before we noticed. Since we left all the dry trees standing in 2020, their natural enemies have also multiplied accordingly. Like the ant-coloured beetle, which eats 30 bark beetles every day. Or the three-toed woodpecker, which also needs 20 cubic metres of dry trees—deadwood—per hectare. We saw more of those too. Then there are X other beetles that we have noticed have increased significantly in population. As a result, we did not have the expected crash in these forests in 2021. Of 675 beetle nests, only about 62-63 remained. So we had a significant decline (Interview "Forester 4", February 2023).

Here, the forester outlines a complex sequence of causal interactions. Storm and snow damage in 2020 weakened forest stands, creating favourable conditions for bark beetle infestation. The outbreak then progressed too rapidly for effective intervention. Yet, contrary to expectations based on prior knowledge of beetle behaviour, the infestation did not continue to spread in the following year. The forester explains this unexpected outcome by noting that beetle predators and competitors also increased, contributing to a rebalancing of the ecosystem.

This account refers not only to ecological processes but also to the process of grasping and explaining them. The anticipated collapse of the forest—based on established knowledge of bark beetle dynamics—did not materialise. This discrepancy between theoretical expectations and ecological outcomes exposes the limits of existing knowledge. Yet it is precisely through such moments of surprise, observation, and reflection that knowledge of the forest ecosystem evolves. The forester's narrative illustrates how an understanding of causal complexity develops retrospectively through sustained engagement with unfolding events over several years.

This raises the question of how bark beetles might behave in a future shaped by climate change. One forester offers a revealing comparison between present and past beetle-related damage:

> A lot of pine trees were damaged in the 1980s. But back then, the damage was somewhat different. It was probably more due to the beetle infestation, and then you always had groups of trees that died off. And now there are a lot… Especially on the shady side, you don't have clusters of trees [next to each other]. You have trees, trees, trees. You have one here, then another healthy one, then another [sick tree]… To me, that means that it's not primarily the beetle [causing them to die]. It's still there. And if what happened [in the 1980s] is now happening again, then you'll have a beetle population that will cause problems. But you can't fight that. You can forget it (Interview "Forester 7(1)", February 2023).

The forester contrasts pine dieback in the 1980s—commonly attributed to air pollution and acid rain—with current dieback, which he associates primarily with drought and climate change. He notes that the damage patterns differ: earlier beetle outbreaks spread radially from tree to tree, whereas contemporary pine dieback appears more sporadic, gradual, and less clearly linked to beetle activity.

Nevertheless, bark beetles remain significant in the context of climate change—not necessarily as an immediately active agent, but as a latent and therefore possible risk. Should climate-induced stress and tree mortality become more widespread, beetle populations may again increase rapidly, amplifying forest damage. The bark beetle thus represents an ever-present causal potential: a force that may remain inactive for extended periods but can be suddenly activated when conditions—such as drought-induced stress—become favourable.

With its complex and often elusive causal role, the bark beetle exemplifies both the natural and epistemological dimensions of the possible. In foresters' accounts, it embodies a causal power that may not currently manifest but remains poised for activation. Because this power cannot be

directly observed or reliably predicted, foresters often rely on simplified causal narratives—such as the heuristic linking of butterfly activity to beetle emergence—to render it intelligible. In doing so, the bark beetle highlights both the contingency of ecological dynamics under climate change and the epistemic challenges involved in grasping them, thereby contributing substantially to the conceptualisation of the possible forest of the future.

Taken together, this section 6.2 has shown how foresters attempt to isolate and identify the causal powers shaping forests as complex ecosystems undergoing transformation under climate change. By linking observed tree mortality to extreme weather events, long-term environmental processes, and biotic agents such as the bark beetle, foresters open a space of possibility oriented toward the future of the forest—that is, toward what may come to be but is not yet actual.

At the same time, integrating these insights into a coherent long-term picture proves challenging from the standpoint of the present moment. Foresters' reflections on their own knowledge, experience, and positionality within long-term ecological change testify to these limits. Yet it is precisely through such reflexive engagement that a field of possibilities for the future forest emerges.

6.3 Imagining the future forest: Possibilities and uncertainties

In this section, I shift the focus from causal interpretations of past and present events in the forest to the emergence of what may arise in the future. The emphasis is no longer on the dieback or disappearance of individual trees or species, but on what might take their place. In other words, I turn to the question of how biophysical nature may adapt to climate change.

I begin by examining how succession theory is mobilised in the case of FACC in Valais, showing that it both informs a specific and seemingly certain vision of the future forest (Section 6.3.1) and generates new forms of uncertainty (Section 6.3.2). I then analyse the troubling significance of this uncertainty for the knowing actor (Section 6.3.3). Finally, Section 6.3.4 demonstrates that the openness of the future is associated not only with uncertainty, but also with moments of surprise and hope.

6.3.1 The unequivocal logic of succession

With regard to the future, a recent scientific paper from Switzerland summarised the current challenge of climate change as follows: "Today's generation of trees has the possibility to adapt or accept losses in growth and vitality; in the worst case, the trees will die" (Streit et al., 2024:30). From the perspective of individual trees, this statement suggests a range of possible outcomes in response to a changing climate. The same applies to entire species and ecosystems: they must

either adapt to changing conditions or disappear and be replaced by other species. Because evolutionary adaptation at the species level typically unfolds over timescales far longer than the pace of current climate warming, the focus in the case of FACC lies primarily on shifts in species composition. The process by which ecosystems respond to alterations in abiotic environmental conditions is commonly referred to in vegetation ecology as *succession*. Over extended periods, new species displace those less well adapted to prevailing conditions, and a new ecological balance becomes established.

Succession theory plays a central role in how foresters conceptualise the adaptation of forests to climate change:

> If you have a pine forest now, then the pine trees will eventually disappear. That's logical. […] The situation is always the same: deciduous trees are becoming more prevalent and conifers are declining. Where we now have spruce trees, pine trees will follow. And the spruce trees will disappear. And the deciduous trees will follow [the pine]. Where there are silver firs and other trees, or some larch, the spruce will follow. Everything is simply shifting at least 200 metres uphill (Interview "Forester 7(1)", February 2023).

This refers to the process whereby climate change causes current forest stands to shift uphill, as temperatures are cooler at higher altitudes. The future forest is thus imagined through a straightforward causal relationship: certain tree species are adapted to specific environmental conditions (in this case, somewhat reductionistically conceived as temperature), and when those conditions change, the composition of species changes accordingly. This central causal mechanism is seen as the driving force behind the emergence of a new forest under climate change. Knowledge about this process emerges principally through theoretical reasoning and is described as unequivocal: "That's logical." It therefore appears certain to the forester that this knowledge will correspond to the real conditions of the future.

According to this account, the forest emerging under climate change appears already determined. Nevertheless, as will be seen in the next two sections, several factors may challenge this interpretation. Before turning to these complications, however, it is useful to consider what such a shift in species composition along the altitudinal gradient might mean in concrete terms, as illustrated by a scientist:

> On the one hand, the limitation will become less severe at the upper forest boundary, i.e. where frost is limited. […] There, tree growth will be stimulated and the tree line will rise. We are already seeing this today. And we are also already seeing an increase or improvement in tree growth. At the other extreme, at the dry limit, where tree or forest growth is limited, mortality processes will occur. In extreme cases, especially in Valais […], the forest's ability to grow could shift. This could actually lead to an expansion of rocky steppes where forests as we know them today would no longer be possible (Interview "Scientist 4", February 2023).

Here again, succession is treated as certain to occur. Yet the implications extend beyond shifts in tree growth and species composition; entirely different landscape features may emerge—forests

where previously there were none, and steppes where forests once stood. The forest as a whole is imagined as moving uphill and being replaced at lower elevations by herbaceous and shrubby vegetation. Although this development remains uncertain for the scientist and lies within the realm of possibility (it "could" be the case), the expansion of rocky steppe is directly linked to the disappearance of forests: "forests are no longer possible." In this sense, the space of possibility for a future forest is closed, as the interplay of physical causal powers excludes the conditions necessary for forest existence.

This limitation of forest viability at the lower boundary—primarily in low-lying, south-facing, and therefore extremely dry areas—represents a central concern. A forester responsible for managing forests at lower altitudes explained this with reference to a slope in such an area:

> It's difficult to imagine that the forest community is actually moving upwards. 200, 300 metres. That's actually possible everywhere, except here, because here we've reached the bottom. There's nothing that can grow any further because this is already an extreme location. So it couldn't really be worse for the forest than it is here. In terms of precipitation, sunlight and temperature. You can't say, "No problem, I'll take the forest and then it will grow back". That doesn't exist. It doesn't exist yet (Interview "Forester 1", September 2022).

From this perspective of climate-driven succession along the altitudinal gradient, forests will no longer exist in low-lying, sun-exposed, and extremely dry locations. This is because such a climatic niche for forests has not previously existed in Valais, and no native tree species is currently adapted to these conditions. From this viewpoint, it appears entirely "possible" to the forester that forest communities will shift uphill—but equally certain that forests cannot persist at the lowest altitudes. A forest adapted to these extreme conditions simply "does not exist" (I return to the word "yet" in this quote in Section 7.2.1, where I discuss the possibility of planting non-native tree species).

Forester 7 (Interview (1), February 2023) likewise referred to the climate-driven "steppization" (*Versteppung*) of areas at lower altitudes. Others emphasised that many of the currently existing steppes are themselves products of human intervention in the landscape, particularly through fire clearance (Forester 5, Interview in February 2023). Still others stressed the biodiversity richness of steppes, highlighting them as an ecological asset for the Valais landscape (Forester 2, Interview in September 2022). I return to these issues in Section 7.1, where I discuss the role of humans in ecological change.

For the moment, it can be noted that references to succession theory—and thus to the causal link between temperature and the distribution of tree species—provide a framework for envisioning a new, climate-adapted forest. This altered forest appears not only possible but even certain. In this regard, succession theory also establishes the conditions for recognising what becomes impossible or absent—namely, forests in extreme locations. With the disappearance of forests in the

lowest parts of Valais, it becomes particularly clear how ecological change is inevitably tied to absences.

This shift in landscape elements—from forest to steppe—appears even more significant than the dieback of individual trees discussed in the previous section. Yet because it concerns only the lowest forest belts in Valais and is less immediately visible than tree dieback, it was mentioned less frequently and in less detail in the interviews. Individual tree dieback therefore emerged as not only easier to grasp empirically but also more entangled with complexities and uncertainties than the seemingly straightforward certainty of succession and steppe expansion. In this sense, the certainty of successional change on the ecosystem level renders the future forest tangible, yet also less concerning, as it is treated as inevitable and largely taken for granted.

6.3.2 The limits of succession

In the previous section, I described how conceptualising forest transformation through succession renders the emergence of a new forest both certain and tangible. Yet this theoretical lens also gives rise to contradictions and ambiguities, as the following quotations illustrate:

> People always talk about certain types of trees coming and certain types of trees going. That may well be due to the warmth. But all the mechanical damage caused by snow pressure and so on… Because there are always heavy snowfalls. Larch and spruce are prepared for that. Deciduous trees may not be able to cope with it. We then have more of them on the ground. […] In terms of precipitation: it rains to 2,500 metres, then it snows again down to the valley floor. And then it gets cold. Then there are these changes. And then it freezes on the trees. The snow. Then we had years where we had a lot of broken treetops. The tops were broken off everywhere. […] So I wonder how well the deciduous trees can cope with that (Interview "Forester 11", October 2024).

> The [adaptation of forests] simply cannot be achieved in 20 years. Most people do not understand this. The forests [are] growing upwards. [But] the soil structure is not able to keep up! […] If the tree species continue to grow upwards, then soil must first be created so that they can grow at all. It doesn't just happen like that (Interview "Forester 4", February 2023).

Both quotations describe similar phenomena: according to succession theory, trees should migrate uphill as temperatures rise. However, other causal forces counteract this process. In the first quote, late-season snowfall persists despite higher temperatures. Subalpine conifers such as larch and spruce are adapted to such conditions, whereas deciduous trees—with their broad leaves and relatively brittle branches—are far less suited to heavy snow loads.[51]

[51] As chance would have it, while writing this section, such an event occurred: in mid-April 2025, heavy snowfall struck Valais within a few hours—even at lower altitudes. By that time, many trees had already leafed out and were unprepared for the weight of the snow. Numerous trees collapsed as a result. Several side valleys lost electricity for hours, some roads remained closed for days, and many hiking trails were inaccessible for weeks thereafter.

In the second quote, soil structure emerges as a limiting factor in the spread of trees: at higher altitudes, soils are often shallower due to steep slopes and the historical absence of accumulated organic material. Tree species with deeper root systems than, for example, the shallow-rooted spruce—including many potentially more climate-adapted deciduous species—can therefore expand only to a limited extent.

Various causal mechanisms thus constrain the establishment and spread of species anticipated through succession. These references make clear that the novel dynamics associated with climate change encounter pre-existing causal structures that persist. Change in nature does not simply entail the disappearance of the old and the emergence of the new. Instead, these layers coexist and interact, giving rise to uncertainty—as reflected in the open question concluding the first quotation: "I wonder how well the deciduous trees can cope with that."

Another source of uncertainty is the absence of tree species expected to appear in the future. When I asked Forester 4 (Interview, February 2023), "What trees should come now instead of spruce?", he replied: "Well, birch, sessile oak, lime. [...] We don't have any lime trees. Nor do we have any sessile oak." According to succession theory and rising temperatures, spruce would be expected to give way to deciduous species. Yet many of these species are currently largely absent from his forest and are not even present in the small numbers that would be necessary for them to spread in the future.

This raises the question of how such species are to arrive and establish themselves as constituents of the future forest. Although seeds may be dispersed by wind or animals, whether this occurs—and how quickly—remains uncertain, as the following forester notes:

> An oak tree doesn't grow quickly. It needs mother trees. It needs birds to carry its seeds. [...] It simply takes time. Of course, it can always grow taller, but it takes a certain number of years to reach that point (Interview "Forester 7(1)", February 2023).

This observation once again underscores that the forest of the future depends on more than rising temperatures alone. Under these conditions, only one thing appears certain: "It simply takes time." Time itself thus emerges as a crucial condition shaping the future forest.

The interaction of causal forces over time is also evident in the following account:

> Some people say that we might end up with Afghan valleys where there is nothing left. I don't know. Maybe. But not as soon as we think. The forest is also resisting. It is a living entity that will try to stay where it is. It will fight. So, I don't think we've reached the end of the road yet. That's how I see it. Not a big cataclysm, but rather a slow process, with the forest moving higher up as temperatures rise. So, it will move upwards. And then, as it gets warmer down below, species that need a little more water will move closer to the water. That's kind of what we're seeing. That's kind of what I've seen over the last 30 years, actually. Gradually. We have pine trees. Before, pine trees didn't grow above 1,000 metres, and now we have pine trees growing at 1,200 metres. I've seen it. So that means that the tree is spreading to other areas. That's kind of how it is (Interview "Forester 8", March 2023).

Here, the forester reflects on one of the most extreme scenarios—complete forest disappearance. Although such a possibility was rarely mentioned in the interviews, it is noteworthy how the forest is described in this context: as engaged in a struggle against climate change. It is not yet exhausted but retains the capacity to resist—a kind of will to live. The outcome of this struggle appears open, at least in the medium term, even though the forester anticipates inevitable change in the long run.

This account is further marked by linguistic indicators of uncertainty. Expressions such as "I don't know" and "maybe" recur throughout, while the repeated use of "I" foregrounds the forester's situated perspective and highlights the epistemic dimension of knowing nature. Temporality once again plays a central role: although the forester draws on three decades of experience ("I've seen it"), he simultaneously acknowledges processes that remain ongoing ("the end of the road" has not yet been reached). He thus positions himself within slow, decades-long transformations—a struggle between forest and climate that shapes the future while generating uncertainty in the present.

Accordingly, climate-driven succession theory provides, on the one hand, a framework that offers a degree of reliability regarding future developments. On the other hand, it raises new questions and uncertainties, many of which stem from causal powers that persist despite climatic change (such as late snowfall or soil depth). The future forest is therefore not conceived purely in terms of novelty or departure from the past. Rather, it emerges through tensions between what already exists and what is anticipated, making it difficult to imagine in definitive terms. This encounter between past and future, old and new, is ultimately actualised in the uncertainty of the present.

6.3.3 When uncertainty becomes troubling

As already noted in Section 6.2.2, I posed a question in nearly all interviews—usually toward the end, as a kind of recap: "What will the forest in Valais look like in about 30–50 years?" Two responses to this question were as follows:

> That's difficult. With the forecasts we have, it's difficult. It's hard to estimate whether things will really continue at this pace. I hope not. […] There's a lot of uncertainty. People don't really trust it yet. *[Long pause before I ask the next question]* (Interview "Forester 11", October 2024).

> *[Pause of several seconds after asking the question]* I don't know. I can't imagine! (Interview "Scientist 4", February 2023).

These responses clearly show that, despite succession theory and the availability of climate scenarios, it appears impossible to form a clear picture of the future forest—uncertainty prevails. I was particularly surprised by the scientist's answer, as his expertise in this field might have led one to expect a more specific response. This surprise is reinforced by the fact that I did not

encounter similarly explicit acknowledgements of ignorance in the scientific literature, especially not when coupled with the markedly emotional exclamation, “I can’t imagine!”

In the face of such uncertainty, a wide range of developments appears possible, as illustrated by the following reference to the future:

> We don’t know how climate is going to change. We have no idea. Maybe suddenly greenhouse gas emissions will… Some people tell me that we could get colder and fall back into an ice age in a few… So now we can see what happened before. But the future? It’s difficult to say (Interview “Forester 8”, March 2023).

Here, the realm of the possible extends even beyond forests and includes seemingly unimaginable scenarios, such as a new ice age. Given this expansive range of possibilities, it is understandable that the future is described as “difficult to say.” The future thus appears radically open and uncertain—yet this openness is grounded in an underlying certainty: that change is already underway.

This dialectic between openness and certainty is further illuminated by the following statement from an employee of the cantonal administration:

> At the moment, we have to assume the worst-case scenario, which basically means that the entire Goms [a high valley in the east of Valais], where we now have spruce and larch forests and a few individual fir trees, will be covered in oak trees in the future. There are currently three oak trees in Goms. […] But it’s impossible to imagine how there could be more oak trees anywhere by 2080. […] So we all find it a bit difficult to imagine how the forests are supposed to change in such a short time (Interview “Government representative 3(1) (cantonal)”, September 2022).

This account illustrates how the difficulty of imagining future forests is closely intertwined with seemingly secure knowledge. It is precisely because climate scenarios and projections exist that people begin to ask what the forest of the future might look like—and it is from this same knowledge base that the difficulty of imagining concrete outcomes arises.

In this sense, it cannot be claimed that the future of forests under climate change in Valais is either entirely open or characterised by radical uncertainty. Not everything is possible. Rather, uncertainty and possibility are themselves conditioned by existing knowledge about the direction in which change is expected to unfold. The conviction that change will occur, on the one hand, and the inability to articulate its concrete form, on the other, ultimately rest on the same epistemic foundations.

The frequent use of “I” and “we” (or, in German, *man*) in these quotations indicates that this uncertainty is not limited to a multiplicity of possible forest states; it also has a deeply subjective dimension. This subjectivity does not diminish the significance of these statements—on the contrary, their meaning emerges precisely through reference to a situated self. It is here that the absence of a clear reference to the future forest becomes analytically salient.

Moreover, the presence of absences in these accounts—visible in pauses, hesitations, and unfinished sentences—underscores the weight of this uncertainty. Uncertainty is not merely stated; it is enacted in speech. In this regard, not knowing what the future forest will be like is experienced as troubling. Even where interviewees attempt to imagine the future, they ultimately acknowledge their inability to do so—and articulate this inability explicitly.

6.3.4 Surprises and hopes

The previous section showed how uncertainty constitutes a troubling moment for actors in the context of FACC in Valais. This uncertainty is rooted in succession theory, which on the one hand provides a means of imagining the future, yet on the other raises a series of contradictions and open questions. At the same time, there are moments of insight that run counter to this prevailing theory:

> [A forester I know] once said something that didn't make sense to me at first: "Look, where there is snow cover for longer periods of time, deciduous trees can establish themselves better than where the snow tends to melt away." Because when the deer are in the woods in spring, when they're moving through, they eat the deciduous trees where the snow has melted, and they don't go where there's still snow. The snow melts later, and by then the deer have moved on to another place. This is definitely the case when you look at eastern slopes, where you actually have almost more deciduous trees than on southern slopes, where you would think it would be ideal for deciduous trees (Interview "Forester 10", October 2023).

According to succession theory and the concept of climatic niches, deciduous trees—generally better adapted to warmer temperatures than conifers—should grow more successfully on south-facing slopes than on east-facing ones. While this expectation appears logical, that is, theoretically sound, it does not align with the forester's observations. The additional factor providing an alternative explanation in this case is deer browsing.

The role of deer, and of wild animals more broadly, will be explored in greater detail in the next two chapters. For the present discussion, it is more important to highlight the fallibility of knowledge evident in this example and the process through which the forester revised his understanding: first through a conversation with an acquaintance, and second through his own observations—both of which can be understood as forms of dialogue with others and with nature. This process renders the theoretical account more coherent and, although not stated directly in the quote, represents a gain in knowledge for the forester—one that enhances his capacity to envision the future.

This process becomes even clearer in the following excerpt. The same individual who had previously remarked on the difficulty of imagining future forests—particularly in light of the predicted spread of oak trees—recounts visiting a high, somewhat exposed valley with other foresters:

> Then I said to them [the foresters]: *[ironical tone]* "With climate change, there should be oaks here, shouldn't there?" [Then they replied:] "Well, yes, there's already an oak tree here." [Then I said] "What?!" There indeed was already such an oak tree there *[shows*

> *the size with his hands].* Shit, that was interesting to know! That means that, in reverse, the climate has already been right for 30-40 years. It survived. Then we can really work fully in this direction (Interview "Government employee 3(2) (cantonal)", February 2025).

This scene again demonstrates the fallibility of prior knowledge: the cantonal employee did not expect to encounter an oak tree at such an altitude—especially not a mature specimen. According to his theoretical understanding, past climatic conditions should not have permitted this. As in the previous example, the insight emerges through dialogue with others.

Importantly, recognising the fallibility of one's own knowledge in these cases is not accompanied by frustration. The forester quoted above appears almost pleased to find more deciduous trees than expected. Likewise, the unexpected discovery of an oak at higher elevations plays a crucial role in helping the cantonal employee imagine the future forest more concretely. From this observation, he infers that oak trees may have been capable of growing there both in the past and in the present—and are therefore likely capable of doing so in the future. In this sense, the openness of the future is associated not only with troubling uncertainty but also with hope.

This dimension of hope is further evident in the following reference, which presents an alternative to succession theory:

> Where we thought there were no pine trees left, they are growing back and doing quite well. So I had come up with a theory that pine trees were doomed, that it was over. But now I'm wondering if the pine trees might come back. My theory [*laughs*], based on global warming, is that maybe the trees will adapt to the climate. The trees that are growing now or that will sprout this year may be able to adapt to this slightly drier and warmer climate. [...] What I see when I enter the pine forest, I see that the pine forest is tending to come back. [...] Now, we may be seeing a comeback, I don't know. [...] But maybe it will lead to less wood, smaller trees, not as tall, but maybe with the same species that may have adapted. I don't know. It's a theory that... Some people, even scientists, say that trees have an ability to adapt. And are they able to pass on the fact that they have suffered from drought to their offspring? Is it perhaps written somewhere in their genetic code? I don't know (Interview "Forester 8", March 2023).

This statement illustrates how succession theory can come into contradiction with certain empirical observations. According to that theory, pine trees should gradually disappear from lower altitudes, or at least grow less successfully. Yet the forester's observations suggest otherwise: "it grows back and grows back quite well." He explains this through a different theoretical lens—namely, the capacity of tree species to adapt to changing environmental conditions through evolutionary processes.

The quote thus points to the distinction between knowledge and reality. The forester repeatedly emphasises that this is "only a theory" and that he does not know whether it is actually true; events may unfold differently than expected. This insight arises, on the one hand, from the inability of succession theory to account fully for certain observations and, on the other, from the availability of an alternative theoretical explanation in the form of intraspecific adaptation.

Although this evolutionary perspective does not provide definitive answers (as reflected in the open questions that conclude the quote), it offers the forester an alternative lens through which to interpret his observations. In doing so, it also becomes a source of hope, suggesting that forests may adapt more successfully to changing climatic conditions than previously assumed. Uncertainty is therefore not only an unfulfilled—and thus troubling—vision of the future; it can also signal that developments may take a different, perhaps less troubling, course than anticipated.

In sum, Section 6.3 has demonstrated that certainty and uncertainty are dialectically intertwined in imagining the future forest under climate change in Valais. Succession theory provides the foundation for both. References to uncertainty and a corresponding space of possibilities are therefore never far removed. Yet while uncertainty is often experienced as troubling, moments of surprise and hope also emerge—and are explicitly valued by the actors themselves.

6.4 Conclusion: The emergence of uncertainty

At the beginning of this chapter, I asked how change in forests as ecological systems is epistemically grasped and rendered tangible. In the case of FACC in Valais, I have shown that climate change is widely assumed—and often explicitly articulated—to constitute a new causal power within forest ecosystems, one that drives transformation. Accordingly, change figures prominently in the accounts analysed throughout this chapter. Yet this change cannot be fully understood in its concrete manifestations by the actors who are thrown into this changing world and attempt to grasp it.

I have shown that references framed as constant conjunctions of events or as causal explanations of isolated events are frequently accompanied by qualifying expressions (“if”s, “but”s, modal verbs, etc.). While recurring patterns—such as gradual tree dieback—may serve as heuristics for identifying causal relations, these references consistently point to the fact that climate change does not operate in isolation. Rather, it interacts with pre-existing causal dynamics on the ground, producing outcomes that resist linear explanation, as illustrated by tree dieback resulting from extreme events, long-term stress processes, or bark beetle infestations.

Anticipated future impacts on forests are therefore grasped primarily through interpretative abstraction grounded in present and empirically observable events. Foresters and other actors are acutely aware of this interpretative dimension and of the epistemic limitations it entails. They reflect on their own knowledge, yet this reflexivity does not yield certainty about the future forest. This becomes particularly evident in relation to succession theory: while succession helps render future forest development more tangible, it does not guarantee predictability. In combination with other causal frameworks, it instead opens up a broad spectrum of possible trajectories—and with them, an increased degree of uncertainty.

This field of possibilities, and the uncertainty that accompanies it, rests on two interrelated dimensions. On the one hand, it draws on references to the indeterminacy, fuzziness and messiness of the biophysical world that foresters encounter and must engage with. On the other hand, uncertainty also emerges from the recognition of, and reflection upon, one's own epistemic limitations. These references to nature and to knowledge about nature should not be understood as a dichotomy. In the case of FACC in Valais, both are consistently present and necessarily intertwined when the situation is analysed from the perspective of individuals thrown into a changing world. In this light, uncertainty cannot be reduced to mere ignorance but must be recognised as a constitutive element of knowing itself.

What stands out most clearly in this chapter, however, is not simply the presence of these dimensions of the possible in the case of Valais, but the active ways in which foresters and other actors engage with them. There is a continuous renegotiation of the language through which dialogue between biophysical nature and knowing actors unfolds. Foresters not only seek to interpret the ecological changes they observe, but also critically reflect on the limits and assumptions of their own interpretations. The "possible forest" thus emerges through a double movement: the causal explanation of biophysical processes and epistemic self-reflection on these explanations. Both are grounded in attempts to relate to a world that ultimately exceeds full comprehension. What emerges, then, is what I would describe as a reflexive form of *known uncertainty*—not simply a lack of knowledge, but an uncertainty that is actively acknowledged, engaged with, and reflected upon.

Finally, uncertainty does not pertain only to the natural world or to knowledge about it; it also extends into the domain of normative practice. While uncertainty is often experienced as troubling, moments of surprise and hope are also explicitly valued. In the following chapter, I examine this normative-practical dimension in greater detail, focusing on anthropogenic agency and its practical enactment under conditions of an open future. In other words, I turn to the question of what it means for foresters to make decisions in a context shaped not only by uncertainty but also by possibility—and what this possibility enables them to do.

Chapter 7: Shaping ecological change: Praxis towards the possible forest

As early as 2008, leading Swiss forestry scientists cautioned against two opposing responses to climate change: waiting too long to act in the face of uncertainty, and adopting hasty or overly radical measures (Rigling et al., 2008). In a jointly authored article in the *Swiss Journal of Forest Science*, they instead advocated an approach inspired by complex adaptive systems and adaptive management (see Section 2.2). This approach combined short- and long-term measures with a comprehensive "status and system analysis of Swiss forests" (p. 317), including field experiments and performance monitoring for "reviewing silvicultural concepts" (p. 320), and the development of new management strategies (p. 321), such as incorporating disturbance events into planning or the controlled promotion of tree-species and genetic diversity.

On the one hand, this intervention demonstrates that uncertainty has long been recognised and reflexively addressed at the scientific level—that is, it has been *known* uncertainty in the sense elaborated in the previous chapter. On the other hand, it also points to a plurality of practical ways of responding to this uncertainty in forestry practice.

In this sense, this chapter turns explicitly to *praxis* in the case of forest adaptation to climate (FACC) change in Valais. It examines how a field of practical possibilities emerges and how foresters engage with it in their everyday work. In contrast to the above-mentioned appeal by scientists to science, politics, and practice in general, the aim here is to empirically investigate how foresters themselves mobilise—or refer to—their own individual capacities for action in order to intervene in forest transformation. In other words, the chapter addresses Research Question 2 (Section 4.3.2): How is individual practice made possible under conditions of forest change?

To address this question, I bring the third dimension of the conceptual framework—normativity—into the foreground. Normativity, however, cannot be understood in isolation. Owing to its constellational embeddedness within knowledge, and knowledge within reality, it always presupposes a situated and partially known context. From the perspective of always-already knowing and acting human beings, this means that foresters not only refer to changes in biophysical nature and to knowledge about those changes, but also adopt evaluative and judgemental stances toward the present situation. Conceptually, this is captured through the dialectic between *what is* and *what ought to be*—that is, how an actual, contextually given situation is judged and transformed through the mobilisation of anthropogenic causal powers.

The chapter proceeds in three steps. First, Section 7.1 examines how foresters conceptualise the role of human beings in relation to a changing forest ecosystem. This includes an exploration of the forest as a landscape shaped by centuries of human intervention and an analysis of what this understanding implies—both conceptually and practically—in the current context of climate

change. Second, Section 7.2 focuses on three concrete domains of practice in which foresters' actions become particularly visible. These practices are analysed as ways of testing, negotiating, and expanding the boundaries of what is considered possible. Third, Section 7.3 turns to foresters as agentive selves, examining how they refer to their own agency and how they understand responsibility and decision-making under conditions of uncertainty.

As in Chapter 6, interviews with foresters constitute the primary empirical basis of the analysis. Analytically, the chapter mirrors the structure of the previous one: selected quotations are presented and interpreted with a focus on how practical references contribute to the emergence of the possible. Each subsection concludes with a brief synthesis of key insights.

7.1 Human agency in the forest ecosystem

This section examines how the role of humans is conceptualised in the case of FACC in Valais. It begins with the notion of the *cultural landscape*, which is particularly salient in this context, as the landscapes of Valais—including its forests—have been shaped by anthropogenic activity over centuries. I first show how these historical influences inform contemporary challenges related to climate change (Section 7.1.1). I then analyse how actors in the field conceptualise the relationship between humans and nature (Section 7.1.2). Finally, I examine how these understandings translate into concrete guidelines for forestry practice (Section 7.1.3).

7.1.1 Forests as historically shaped cultural landscapes

As shown in the description of the present case (Section 5.1.2), the landscapes of Valais—particularly at lower altitudes—have been shaped over centuries by local populations, most notably through the use of traditional irrigation systems known as *bisses* (French) or *Suonen* (German). These systems also influenced areas typically regarded as "natural." For example, southern slopes previously considered too dry for cultivation were rendered arable, enabling the expansion of agriculture. This transformation also affected forests: some were cleared or burned to create meadows, while others were used as pastures for livestock. Many of the iconic rocky steppes in Valais are direct results of these practices.[52] At the same time, certain forests were deliberately preserved as protective forests for villages located on the slopes.

Through such land use, the landscape of Valais became what is now referred to as a *Kulturlandschaft* (cultural landscape), a term formally recognised in the cantonal forest law of Valais. The law is intended to serve "the protection of the forest as a natural community and element of the

[52] The rocky steppe (*Stipo poion*) is a biotope characterised by a continental climate and dry grasslands with sparse vegetation composed primarily of tussock grasses and geophytes. Within the Alps, it occurs mainly in inner-Alpine valleys such as Valais and the Engadin. Owing to these conditions, rocky steppes host numerous rare plant and animal species and are therefore considered biodiversity hotspots.

cultural landscape" (Grosser Rat Kanton Wallis, 2023:Art. 1). Anthropogenic interventions in the forest over the centuries are thus captured by the concept of *Kulturlandschaftswandel* (cultural landscape transformation), as explored, for example, by Kempf (1985) and Bätzing (2018:72–127). Contemporary changes driven by climate change therefore form part of a much longer history of landscape transformation in Valais.

The practice of forest grazing has had a major impact on current efforts to adapt forests to climate change. Until the 1960s, livestock were driven into forests, especially during the winter months when forage was scarce. Grazing animals consumed not only herbaceous plants but also the shoots of young trees—particularly those of deciduous species, whose leaves are easier to eat than the pointed needles of conifers. Ironically, conifers such as pine and spruce—already less resilient to climatic stress—were less affected by grazing, while deciduous trees, which are generally better adapted to warmer conditions, were disproportionately suppressed (see, for example, the interviews with "Forester 2" (September 2022), "Forester 4," and "Forester 5" (both February 2023)).

This dynamic has also been examined by scientists (see Gimmi and Bürgi, 2006; Gimmi et al., 2008; Gimmi et al., 2010), whose work emphasises the distinct yet intertwined effects of past land-use change and contemporary climate change. For instance, the current decline in pine trees is largely attributed to drought stress associated with climate change, whereas the resurgence of deciduous species is likely linked to the abandonment of forest grazing in recent decades (Gimmi et al., 2010:18). These processes cannot be considered in isolation, as the following excerpt from a report by a forestry engineer illustrates:

> Using the example of the silver fir, which is better equipped to cope with climate change than spruce, researchers have found that it should actually be more widespread. Its very limited distribution is solely due to human influence, either from goat grazing in the forests in the past or today's excessive game densities. The same applies to other species, which is why it would be important to know more about their natural potential for expansion. Greater mixing of Valais forests with silver fir and deciduous trees would certainly mean better stability and resilience for the stands (Métral, 2015).

This statement refers to a possibility—not one projected into the future, but one concerning the present: the silver fir (*Abies alba*) "should" (and therefore could) be more widespread had it not been for historical goat grazing. This possibility thus possesses not only a natural dimension (what could be otherwise in nature) but also a normative one: in light of climate change, a broader presence of silver fir would be desirable. This reading also helps interpret the subjunctive clauses in the latter part of the quote: it would be important to know more about the species' "natural potential" in order to promote greater species diversity. Neither condition is currently fulfilled, yet both remain within the realm of the possible. Here, the possible is clearly connected to the normative dialectic between what currently is and what ought to be.

In interviews, foresters likewise referred to this historical land use and evaluated it through the lens of present-day climate concerns:

> We just have this damn fucking [*hüera scheiss*] spruce! It's everywhere! On the one hand, it's a natural forest in that sense. But it has certainly been shaped over centuries because there used to be a lot of goats. […] The goats ate all the leaves! (Interview "Forester 4", February 2023).

> So if there is a bit of diversity [in the forest], [adaptation to climate change] is absolutely no problem. It's just the [forests] near the villages […] where it doesn't work. The sunny sides, which have always been cultivated anyway, through agriculture. I mean, there's still a bit of chemistry missing [*figuratively speaking*]. Otherwise, things are actually going very well. […] In areas where cows have grazed, it's difficult (Interview "Forester 11", October 2024).

In this sense, the current state of the forest is shaped by the causal legacies of past forest grazing. The first quote in particular highlights the interplay between natural processes and human interventions. Today's forest is a product of this interaction—even though it is still commonly labelled "natural."

It is clear—both from the stark language of the first quote and the more measured tone of the second—that these past practices are viewed critically in light of current challenges. The prevailing sentiment is that it ought not to be the way it is. This historical legacy now poses difficulties for foresters, as tree species that would be valuable under future climatic conditions are missing from the current forest composition. In this context, natural succession toward a climate-resilient forest cannot unfold as it ideally might.

However, these historical practices should not be judged solely by contemporary standards. They may not align with current goals, yet they were rational within the frameworks of their time. A forester described reforestation efforts from roughly a century ago:

> My predecessors were part-time foresters and they carried out this reforestation. They planted the larch, spruce and pine trees. They deserve a lot of credit. They have turned out really well in this setting. They have really taken root and they looked after them. But they had a perspective. They knew that this [these trees] would grow like this (Interview "Forester 11", October 2024).

A scientist echoed this reflective stance in evaluating early twentieth-century reforestation:

> What seems a little strange from today's perspective is the composition of tree species [that was used], and that's not… You have to be careful not to assign blame here. These were intelligent people who thought things through carefully, but the context at the time was simply different (Interview "Scientist 3", September 2022).

The scientist observes that the species selected for planting then do not correspond to what would be considered climate-appropriate today. Like the forester in the previous quote, the scientist offers a historically situated and nuanced assessment of past decisions. Reforestation strategies were based on assumptions of long-term climatic stability—"they knew that this would

grow like this"—and climate change was not yet a consideration. From today's vantage point, however, those species compositions are no longer seen as desirable. The speaking subjects thus evaluate previous actions while simultaneously reflecting on the positionality from which this evaluation is made.

One might argue that such judgements are irrelevant, since the past cannot be changed. Yet from a practical standpoint, working with the structural legacies of the past is essential. Doing so requires not only historical understanding but also critical assessment in order to identify how and where to intervene within the complex and dynamic structure of the forest.

Accordingly, the forest system in the present case cannot be fully understood through "natural" processes alone, even though so-called natural forests are often described as the least susceptible to the effects of climate change (Scherrer et al., 2023). Anthropogenic influences—both past and present—are already at play and must be accounted for in any serious analysis of future forest trajectories. These historical influences are therefore evaluated from a contemporary standpoint that is both differentiated and self-reflective, yet unmistakably normative.

7.1.2 Rethinking human-forest relations

In the previous section, I demonstrated how past human interventions—though rational and understandable within their historical context—continue to complicate both the interpretation of forest dynamics and the capacity to intervene in them. In light of anthropogenic climate change, the question arises anew: how should individuals or society intervene in the forest, and which norms should guide such interventions? Addressing this question requires a closer examination of how anthropogenic and natural causal powers are conceptualised in relation to one another.

This debate reflects a paradigm that has become widely accepted in forestry over recent decades: sustainable forestry is understood as forestry that remains close to nature—that is, management practices that account for site-specific ecological conditions (see Section 2.2; see also Kaufmann et al., 2010; Brang et al., 2014). In the face of anthropogenic climate change, this strategy appears to be gaining further traction in Valais. Several foresters articulated this position unequivocally: "In the forest, the natural is always best" (Interview "Forester 8", March 2023); "We have to let nature take its course" (Interview "Forester 7(1)", February 2023); and "Just follow nature's example and you can't go wrong" (Interview "Forester 6", February 2023).

However, other interview statements complicate—or even challenge—this apparent consensus:

> I had people before me who did some work that I am now reaping the benefits of. So it's not all external factors. Ultimately, humans are also part of change, both directly and indirectly. When you harvest, you have an impact. So you also change the energies in your forest, you change the dynamics, so it's always of all that (Interview "Forester 8", March 2023).

This statement refers back to the historical human influence outlined in the previous section. The forester points to earlier generations who actively intervened in the forest, underscoring that the forest is neither now nor has ever been a purely natural or untouched entity. Rather, it is an ecosystem shaped—at least in part—by human activity over decades. Humans are therefore not external to the forest but "part of change." This understanding serves to justify present-day interventions rather than a passive stance of simply letting nature take its course.

Even the forester who initially advocated non-intervention moves in a similar direction: "We can support nature through the interventions we make" (Interview "Forester 7(1)", February 2023). The forest thus does not appear as an external force dictating a singular course of action; instead, humans are understood as constitutive participants within it.

Accordingly, the prevailing perspective is not one of strict dichotomy between humans and nature. Rather than an either–or logic, foresters frequently speak of "cooperation with nature" (Forester 8, March 2023). This collaboration can take unexpected forms. Forester 2, for instance, described with enthusiasm the biotic symbiosis between jay birds (*Garrulus glandarius*) and oak trees. In autumn, jays collect acorns and bury them as winter provisions; when some are forgotten, they enable the natural spread of oak. Given the greater climatic resilience of oak compared to pine, the forester proposed the following:

> [Here you see] where the pine forest transitions into oak forest. The young oaks are two or three metres tall, and the jays planted them. In autumn, I think [you should] shoot jays in these areas, then the oaks will be planted. The dead [jays] won't eat them anymore because they can't anymore because they're dead. That would be reforestation. […] You could do that. That's my idea [*laughs*] (Interview "Forester 2", September 2022).

The macabre tone of this quote should not obscure the underlying conception of the human–nature relationship. Cooperation with nature appears inherently paradoxical: on the one hand, human practice aligns itself with natural causal cycles such as seed dispersal; on the other hand, these cycles may be deliberately interrupted. Silviculture is therefore not merely a matter of "following nature's example," but also of active intervention—even when this involves disrupting ecological processes.

While all interviewed foresters described their practice as some form of collaboration with nature, the concrete meaning of this relationship varies considerably. Moreover, this principle is often contrasted with practices in other regions where it has historically been less influential. Frequently cited examples include forest management on the Swiss Plateau and in parts of Germany, where timber production long took precedence over the protective functions that characterise forestry in Valais:

> Finally, a quick aside. We're talking about the drought in the beech forests. Or the bark beetle problems in the plateau forests. […] There shouldn't be any bark beetles on the plateau! There shouldn't be any spruce trees on the plateau! Maybe we should have 10% spruce trees on the plateau and the rest should be beech, maple and cherry trees. […]

> And what did we do? We planted fir and spruce in the plains. So, great *[ironic undertone]*! It looks like it's growing well, it's clear that it's growing fast. […] The Germans made the same mistake. The Czechs made the same mistake. Almost all of Europe made the same mistake (Interview "Forester 8", March 2023).

Here, the forester articulates explicit normative claims about what ought—and ought not—to be done. These judgements are supported by references to present-day forest problems, which are implicitly traced back to ecological mechanisms: extensive spruce planting in the twentieth century almost inevitably increased vulnerability to drought stress and bark beetle infestation. From this perspective, such practices ran counter to site-specific ecological conditions and should therefore have been avoided. The normative orientation invoked here is thus grounded in biological realities.

Against this backdrop, the discourse of collaboration with nature can be understood as a counterpoint to earlier practices such as monocultures and commercially oriented forest steering—approaches that, although less dominant, also left their mark on Valais forestry. Foresters therefore increasingly conceive of their practice as aligning with the causal powers of nature rather than working against them:

> In forestry, you have to go back to natural structures more and more and simply say, "We have to do things the way nature intended." They never did that in the past. In these commercial forests, they wrote, "There's this type of soil, so you can plant this and that." That's how we learned it. Whether or not this was a natural structure was ultimately irrelevant. And even earlier, they simply planted the wood that they could use for construction. […] I would say that foresters are getting closer and closer to nature-based work. Or working with nature. You have to accept more and more that there is no other way (Interview "Forester 7(2)", October 2024).

In this quote, the natural forest is framed not merely as a normative ideal but as a practical necessity. The wording suggests an absence of viable alternatives, justified by past failures to adequately account for ecological conditions. The implication is clear: avoiding the repetition of such mistakes requires forest management to accommodate—or even defer to—natural processes. "Cooperation with nature" thus signifies not only a possibility but also a normatively charged imperative, at times approaching a prescriptive must.

Yet applying this principle under conditions of climate change introduces new challenges:

> Until now, it has always been said that we should learn from nature. And now, apparently, if things happen too quickly, we can no longer learn anything [*laughs*] (Interview "Forester 11", October 2024).

This statement highlights a central contradiction. On the one hand stands the normative commitment to collaboration with nature; on the other, the recognition that knowledge about nature is itself marked by uncertainty. To work with nature presupposes a certain degree of understanding—but climate change destabilises precisely this assumption. As argued in the previous chapter, past patterns cannot be relied upon to predict future conditions with confidence. This

undermines the empirical foundations of what has traditionally been regarded as "natural" knowledge and, by extension, challenges the epistemic basis of close-to-nature forestry.

7.1.3 Navigating change through diversity

Despite the absence of certain knowledge about biophysical nature, interventions remain unavoidable, for non-intervention is itself a form of practice. The question, therefore, is not whether to act, but how to do so under conditions of uncertainty. Put differently, how can a desired forest be cultivated amid climatic transformation and incomplete knowledge? As the following forester suggests, however, this question may itself rest on a misleading premise:

> What strategy am I going to adopt, or what plant can I put in place now? […] For me, [like that] we're not going in the right direction. It's more like saying: what can I do with what I've already got? Because what I already have is there, and it's already been suffering from rising temperatures for years (Interview "Forester 8", March 2023).

The strategic orientation proposed here is precisely the avoidance of overly rigid guidelines for controlling the forest. The extreme form of such control—discussed in the previous section—is the large-scale planting of uniform forests, as historically practiced in parts of the Swiss Plateau and Germany with a primary focus on timber production. By contrast, contemporary practice is less concerned with implementing a fixed vision of the future and more with working responsively with what already exists and proves viable.

This shift becomes particularly evident in the forester's reformulation of the guiding question. Although the "I" remains central, the emphasis moves from "What do I put in place?" toward "What can I work with?" The focus thus shifts from imposing anthropogenic causal force to acting in relation to the causal powers already present in the ecosystem. What exists becomes a practical orientation for future action; the forces of nature themselves begin to indicate possible trajectories.

Yet this does not imply passivity. The same forester described more concrete interventions as follows:

> I think the main challenge for us is to break up the regularity of the forests. […] I've always tried to mix fir, larch, spruce and pine. […] That way, you know there's a problem, but we have at least room for manoeuvre because in the mountains you're more limited. But when you have a problem with one species… When you have a forest with three or four species, you're safe in a way. And the better the equilibrium, the stronger your forest is. That's crystal clear. Unstable forests are forests where all the trees are the same age, the same size and the same species. You know that one day you'll have a problem. When you manage to break that up and introduce some structure[53], it's great for climate change (Interview "Forester 8", March 2023).

[53] The term *structure* in forestry vocabulary is often used to refer to diversity in terms of age, height and species of trees.

The strategy articulated here is one of diversification. The aim is to cultivate as wide a range of differences as possible—in tree species, age, and structural composition—so that disturbances affect only limited parts of the forest while the overall system remains stable. The concept of resilience thus emerges as a central practical orientation.

Succession theory traditionally assumes that, under largely undisturbed conditions, forest ecosystems pass through long cycles lasting decades or even centuries. Overaged and structurally homogeneous stands eventually collapse—often facilitated by disturbances such as fire or pests—thereby creating space for regeneration. From an anthropogenic perspective, however, forests are expected to fulfil continuous social functions, particularly protective ones in Valais. Such functions cannot be suspended during phases of ecological collapse. Under historically stable climatic conditions, the forester's task therefore consisted precisely in interrupting these cyclical dynamics to maintain functional continuity.

This normative orientation persists under climate change. As suggested in the quote above, the forest should remain in "equilibrium," "safe," and "stable." Diversity becomes the means through which anticipated disturbances—"you know there's a problem"—can be mitigated in advance. Faced with an uncertain future, risk reduction is actively pursued in the present.

Accordingly, forests are expected to exhibit diversity—often described in forestry terminology as *structure*—and silvicultural practices are increasingly guided by this principle. In practical terms, this includes thinning overaged stands to promote regeneration and selectively supporting underrepresented species. Successional models play an important role in identifying species considered better adapted to future climatic conditions:

> The protective forest above [*name of a village*] is undergoing change. The growing deciduous trees are replacing the existing and weakened pine trees. By selectively removing pine trees, we are supporting and controlling this natural process *(excerpt from a poster by a forest company observed during fieldwork)*.

Succession theory thus provides directional guidance for intervention and can serve as a normative justification for action. Yet the conceptual difficulties surrounding succession discussed in Chapter 6 also translate into practical challenges, as the following forester explains:

> Now we are suddenly supposed to leave this birch tree standing. That is difficult, yes. Because after 100 years, the birch tree will fall down again anyway. These are not really the types of wood that one would naturally choose for the future. Changing this attitude is difficult. […] Until now, of course, there has been a strong focus on larch and spruce. Swiss stone pine. And now suddenly we are supposed to focus on hardwood. That is difficult. But when you see that this is the direction things are going in, there is no other option. […] This will require a rethink in forestry (Interview "Forester 11", October 2024).

The forester notes that birch trees (*Betula sp.*) are no longer routinely felled during logging because they are better adapted to warmer and drier conditions than many conifers. Birch, however, is a pioneer species that rarely persists over centuries and is eventually displaced by later-

successional species. Historically, it was not regarded as a foundation for long-term forest stability. Under conditions of climate change, however, this evaluation is being reconsidered, and birch is increasingly retained despite its comparatively "short" lifespan of roughly one century.

This adjustment appears to generate a degree of professional unease ("that is difficult"). The shift in practice is justified by the assertion that there is "no other option" if climatic developments continue to favour deciduous species. What foresters ought to do is thus grounded in reference to ecological dynamics that exceed direct human control.

At this point, one might ask what room remains for individual agency. Can foresters still make meaningful decisions, or are they compelled merely to adapt their practices to natural developments—even though, as Chapter 6 has shown, knowledge of these developments is itself uncertain? Here, the concept of the possible becomes particularly salient, for agency presupposes that the future is not fully predetermined. This is clearly illustrated in the following quote:

> When there are such extreme climatic changes, there's nothing you can do. There are limits somewhere. In that sense, the measures we are taking are soft measures. But they are actually successful. That's clear. The consequences in protective forest management are already having an impact. We've been doing this since around [the year] 2000. That's when we started to focus consistently on regeneration. On diversity. […] Although it's still relatively difficult for us. […] The higher you go, the fewer tree species grow. You can't just say, "Where there are lots of larch trees, it would be nice to plant some rowan trees for the birds." It doesn't work like that. Everything has its limits (Interview "Forester 5", February 2023).

The forester delineates the boundary between what is practically possible and what is not—boundaries consistently tied to biophysical conditions. The account moves from practical impossibility ("there's nothing you can do") in the face of extreme climatic scenarios, to actionable possibilities such as promoting natural regeneration and diversity, before returning to measures deemed ineffective or unfeasible, such as planting trees at higher altitudes.

Once again, diversity plays a central role. It is understood not only as a factor enhancing ecological resilience but also as something that can be actively fostered through human practice. Promoting diversity thus becomes a strategy that links the indeterminacy of the future with the principles of nature-oriented forestry while simultaneously preserving space for anthropogenic intervention. In this respect, the three dimensions of the possible developed in Section 4.3.1—natural, epistemological, and practical—appear as mutually constitutive.

Notably, diversity is also widely endorsed within Swiss scientific literature (e.g., Brang et al., 2016; Frehner et al., 2018) and in policy communications (Métral, 2015:64–65; Jordi, 2017; Dussault, 2023) as a pathway toward climate-adapted forests, suggesting a broad degree of institutional consensus. The following section, however, identifies three areas in which the strategy of diversity and natural regeneration encounters practical tensions, thereby illuminating the shifting boundary between the practically possible and the impossible.

To summarise the insights of Section 7.1: the possible forest emerges not only through references to causal forces in nature and the ways they are known through the interplay of empirical observation and theoretical explanation, but also through anthropogenic causal powers. The historical shaping of the landscape reveals the forest in Valais as a stratified socio-ecological system in which past interventions continue to exert influence in the present. Within this context, nature-oriented forestry—and the ideal of cooperating with natural processes—gains increasing prominence, particularly under conditions of climate change. In practice, this orientation translates into the promotion of diversity across tree age, species, and structural composition. Crucially, however, this strategy is shaped not only by ecological dynamics and the limits of knowledge, but also by the normative commitment to maintaining forest stability over time.

7.2 Exploring and expanding the limits of the future forest

In this section, I examine in greater depth forestry practices that seek to enhance diversity in response to climate change, thereby expanding the space of the possible for the future forest. Particular attention is paid to the constraints and challenges these practices encounter. I begin by analysing the case of plantations involving tree species considered well adapted to future conditions (Section 7.2.1). I then turn to Robinia as an example of a non-native, invasive, yet potentially climate-resilient species (Section 7.2.2). Finally, I explore the relationship between forest and wildlife management, which assumes particular importance in the adaptation of forests to climate change (Section 7.2.3).

7.2.1 Plantations as experiments in future forests

When climatic conditions change, the biological components of an ecosystem must also transform in accordance with the principle of succession—that is, new organisms and species must migrate. However, as shown earlier, these two components (climate and biology) operate on different timescales in the present case: trees may not reproduce and spread quickly enough for new stands to establish themselves in suitable locations. From an anthropogenic perspective, the most straightforward option would therefore be to accelerate this process by planting trees from warmer and drier regions in areas expected to experience similar climatic conditions in the future.

In Valais, this may initially appear relatively uncomplicated given the pronounced altitudinal gradients: species currently growing at lower elevations could simply be planted higher up. Yet, as Section 6.3.2 has demonstrated, other factors—such as slope exposure and soil characteristics—must also be favourable. Even when these conditions seem to be met, practical implementation is far from straightforward, as one forester explains based on his own experience:

> It just doesn't work if you just plant trees in pots. The microclimate has to be right too. We have experience of this in [*name of a specific forest*], for example. It's a steep slope. Almost nothing grows there. It's hell in summer. There's no water anywhere. We carried out a reforestation project there. […] We thought we knew how to do it. […] We even got soil from the forest so that we could put the mycorrhizal fungi back into the forest. It was a huge effort. We planted about 10,000 trees on 3 hectares. In the first and second years, they actually grew very well. Then came the hot summer of 2003. Over 90% of them died. At that point, we didn't know anymore what to do. […] Once all the trees were dead, we said to ourselves: we can't go through the whole planting process again. We had no more ideas (Interview "Forester 4", February 2023).

The forester vividly recounts how he and his team undertook considerable efforts to plant trees on a dry slope. In theory, the project should have succeeded. However, the exceptionally hot summer of 2003—an event they had not anticipated—proved decisive. Drawing on their experience from the 1990s, they had not considered such extreme heat to be possible. The newly planted trees did not survive, and the team found themselves with "no more ideas." What emerged from this episode was a confrontation with the limits—and, indeed, the absence—of knowledge. The failure also had practical consequences: such planting efforts were no longer regarded as viable. It thus provides a striking example of how an unforeseen extreme event can render a particular forestry practice impossible.

One way to render such planting feasible again would be through irrigation (see Figure 11, p. 148). Yet a forester who frequently experiments with irrigated planting is acutely aware that forests cannot be watered indefinitely:

> One vision we have is to only water for the first five or ten years and then reduce until we reach zero. That would be the dream goal, if it were possible, because then we could start regeneration in island-like areas. And wherever you start, you sprinkle water. That would mean we could actually start with a relatively large area. […]. [But] I don't know if we have that much time. I hope we have some time. If things continue like this with the water and the temperature, we don't have much time. Because what we are doing now is too water-intensive. We need to be able to further reduce the water we still have (Interview "Forester 1", September 2022).

What is particularly noteworthy in this quote is how the forester articulates his desired objective. Once again, it is framed through a conditional: if this irrigation strategy proves effective over a period of five to ten years, planting could be expanded across a larger area. This projection is immediately tempered, however, by a caveat—the forester does not know whether sufficient time will be available for the strategy to succeed. It therefore remains uncertain whether present conditions will even allow this objective to be realised.

Time thus emerges once more as a decisive factor—both in relation to the direct effects of rising temperatures on forests and to the availability of water. Many mountain streams that currently supply irrigation water are fed by snowmelt and glaciers at higher altitudes, both of which are expected to decline under climate change. This again underscores how numerous natural mechanisms must align for human interventions to be not only possible but also effective.

Figure 11: Irrigated test planting of different tree species at the Lötschberg South Ramp (Source: Photograph by the author, 3 August 2022).

Another challenge associated with planting is the limited availability of suitable tree species, particularly in low-lying areas. One forester refers to this issue:

> The question now is simply how much it will affect us. If the forecasts are correct, if we have those five degrees more, we will slowly start to have Italian climate conditions here. We might have evergreen trees then. We could try planting cork oak or devil knows what. We have to give it a try. But that's always a problem, of course. If you don't have the right tree species, you have to go and get them first. And that's almost impossible in such a dry climate. You'd have to water them. If I plant something here, I have to water it. Otherwise, 100% of it will die. And that's not financially viable, and you're also sending the wrong signal when you water these trees. At some point, you have to stop (Interview "Forester 7(1)", February 2023).

Here, a sequence of conditionals concerning the forest's future translates directly into practical reasoning: if temperatures rise by five degrees, southern species such as cork oak (*Quercus suber*) or other evergreen trees might be introduced. Yet if the forester plants such species, they must be watered—and watering, in turn, provides what he considers the wrong ecological stimulus. Thus, while the conditions under which planting might become possible are carefully outlined, their overlap renders the practice "almost impossible."

Nevertheless, according to the forester, such efforts should still be attempted—indeed, "one must give it a try." Here, the notion of possibility is translated into a practice of experimentation. Experimentation can therefore be understood both as a way of probing the limits of what is possible and as a means of expanding those limits. Without such planting initiatives, certain tree species would never have the opportunity to establish themselves in specific locations at particular moments in time.

7.2.2 Managing invasiveness: The dilemma of Robinia

When planting trees, the question inevitably arises as to which species should be selected. A similar debate concerns non-native tree species. Several such species have already been introduced in parts of Valais—for example, Douglas fir (*Pseudotsuga menziesii*), black pine (*Pinus nigra*), and Robinia (*Robinia pseudoacacia*)[54]. While the heated discussions surrounding Douglas fir appear less intense in Valais than elsewhere in Europe (see, e.g., Derks, 2019; Pukall, 2019; Wollrath, 2022), Robinia remains particularly controversial (for the history of its introduction in Europe and its multipurpose uses, advantages, and risks, see Vítková et al., 2017; Vítková et al., 2018; Nicolescu et al., 2020).

In both Switzerland and Valais, Robinia is classified not only as a non-native species but also as an invasive one. It is listed among species "that cause proven damage to the environment" (Amacher et al., 2022:56) due to its rapid spread and negative effects on local biodiversity. In Valais, it is actively controlled in some areas—particularly in nature reserves and along riverbanks, where there are concerns that seeds may disperse via water (Kanton Wallis, 2017). Although the decision to control Robinia is made by governmental authorities, the practical work is largely carried out by foresters. One forester describes the eradication efforts as follows:

> We're still trying to eradicate [Robinia]. [*laughs*] […] This year, we ran a major campaign to get rid of it. Personally, I would have left it. But since it's on the list of invasive plants… Because it doesn't cause many problems here. […] The Robinia is taking root. If there's a maple tree next to it, it won't take its place. But we decided to eradicate it anyway. […] For me, it's not something that's very problematic. […] Maybe we should have integrated it into our forestry system. For me, it's quite a part of… What's more, it makes wood that can still be used (Interview "Forester 8", March 2023).

Yet the forester believes that Robinia should largely be left in place and integrated into the forest. While official regulations justify efforts to combat the species, his assessment draws on personal experience: Robinia does not appear to crowd out other trees and produces valuable timber. From this perspective, the species should be incorporated into forest management rather than systematically removed.

[54] The usual English name for *Robinia pseudoacacia* is *black locust*. I use the term *Robinia* here because it more closely reflects the German *Robinie* and the French *robinier*, which were also used by interviewees.

Another forester expresses a very similar view:

> It stabilises the embankments, it does a great job. It makes excellent wood. It's perfect. [*sighs*] We're struggling with Robinia today. I wonder: does it even make sense to fight it anymore? Ultimately, it tolerates dry conditions, so it would suit us. It also tolerates a lot of rockfall and other things, and is very resistant. Sure, it doesn't fit in. But I tell myself: maybe we need to look at it differently today (Interview "Forester 5", February 2023).

This quote adds further arguments in favour of Robinia: it stabilises embankments and tolerates drought and rockfall. These characteristics are referred to as causal properties of the species, about which there appears to be little epistemological doubt. At the same time, such properties gain particular relevance under conditions of climate change. The normative value attributed to Robinia thus derives from its biological characteristics but is simultaneously socially embedded: these traits acquire significance because of the pressing need to maintain protective forests despite changing climatic conditions. The forester recognises Robinia's value precisely through the interplay of these elements, which converge in everyday practice.

The emergence of this valuation is also linked to the uncertainty with regard to climate change, as a scientist explains with reference to the Valais region:

> There are foresters who have forests on the southern slopes in the lowlands who simply say, "Yes, we'll just have to switch to other tree species." In Switzerland, there is simply no other option, no alternative. What is now spreading is Robinia. People are considering whether it should be accepted as a good tree. […] In Valais, I think the trend is more towards allowing it on the southern side. Because it simply has a few good qualities. It doesn't dry out properly. It stabilises the soil. It provides good wood; in other words, the wood is practical. So I think people are open to it there. […] That's how you deal with uncertainty. You're already a bit perplexed, even when droughts come and lead to huge premature leaf fall in the Lower Valais. Then you're unsure where this is all heading. I think that with this increasingly precarious situation, people are becoming more open to such alternative solutions (Interview "Scientist 4", February 2023).

From the external perspective of the scientist, it becomes apparent how uncertainty can serve to justify the normative assessment of Robinia as "good." In this sense, uncertainty—and the field of possibilities it opens—may itself function as a causal factor that enables or suspends particular practices. Here, it suggests that active intervention to combat Robinia may not necessarily be warranted.

It should also be noted that controlling Robinia is highly labour-intensive. While young plants can be pulled or dug up, mature trees require removal of the rootstock after felling to prevent coppicing[55] (see, for example, Kanton Wallis, 2022:5–8). A somewhat less demanding method is known as "ringing" (*Ringeln*), which involves removing part of the bark. This allows some nutrients and water to continue reaching the crown, but the tree dies gradually over time (see Figure 12, p. 151).

[55] Coppicing refers to the growth of new shoots from a tree stump after the main stem has been removed.

Figure 12: Example of "ringing" Robinia alongside the Rhône River near Sierre (Source: Photograph by the author, 29 March 2023).

In this context, decisions about whether to combat Robinia often involve weighing competing interests:

> So they're already there, and we're not getting rid of them. Basically, we don't want Robinia trees in nature reserves; we want to keep the area relatively open. But that's a bit like fighting windmills, I would say. […] If you cut them down, they'll be two metres tall again a year later. That's not bad, actually, when you look at the tree. It's a very robust tree species. It just has the disadvantage of taking nitrogen out of the soil. Then, of course, nothing else around it stands a chance. That's logical. But you can't have your cake and eat it too [*man kann nicht den Fünfer und das Weggli haben*] (Interview "Forester 7(1)", February 2023).

This statement clearly illustrates a normative evaluation of the species' advantages and disadvantages. From the forester's perspective, Robinia's traits are treated as inherent: its robustness, rapid regrowth after cutting, nitrogen fixation—which can inhibit other species—and the simple fact that it is already present. The decision therefore concerns which of these properties should be prioritised in practice.

Practically speaking, both courses of action remain possible: intensive control measures can be undertaken, or Robinia can be allowed to persist. Each option carries specific causal

consequences, yet both cannot be pursued simultaneously—choosing one effectively excludes the other.

The very existence of this field of practical possibilities—and its significance—stems from the diversity of natural traits exhibited by Robinia. These traits create a degree of openness that necessitates a practical decision. More important than the decision itself is the fact that a choice exists—that openness is present. Foresters actively engage with this possible and reflect upon it through their practical experience, thereby contributing to the broader uncertainties already described. Uncertainty thus arises not only from the multiple pathways through which causal powers in nature may unfold, or from incomplete knowledge about them, but also from the plurality of practical actions available and the normative evaluations that guide their selection.

7.2.3 Browsing the future forest: Wildlife as a constraint on adaptation

As explained in the two previous sections, a key concern in forest management under climate change is ensuring that the "right" trees are in the right place at the right time. Due to the challenges associated with planting non-native species, the focus is primarily on trees that regenerate spontaneously in the forest—referred to as natural regeneration (*Naturverjüngung*). In practical terms, this involves promoting the growth of young trees that emerge naturally (for example, by felling older trees that block light from reaching the forest floor), particularly those species considered better adapted to changing climatic conditions. However, another factor also plays a decisive role in the emergence of natural regeneration:

> Our forests [...] are badly regenerated. This means that the majority of trees between zero and 80 years old are missing. If we experience another severe decline in the old stock [as in recent years], we will really have a problem because we have no young trees. We have a very high game population. All the young trees are simply being eaten. [...] Now climate change is coming into play. It's like a booster. It's speeding everything up considerably. Now we have almost no time left (Interview "Forester 4", February 2023).

The desired natural regeneration is therefore not occurring in many forests—it should be happening, yet it is not. The causal force preventing this regeneration is wildlife. In this context, the primary species involved is the red deer (*Cervus elaphus*), although roe deer (*Capreolus capreolus)*, chamois (*Rupicapra rupicapra*), and ibex (*Capra ibex)* also contribute. These animals feed on the buds of young trees during winter, when other food sources are scarce, thereby hindering their growth. Deciduous species, regarded as better adapted to future climatic conditions, are particularly affected (see Figure 13, p. 153). This issue closely parallels the historical forest grazing discussed in Section 7.1.1.

In the quote above, the forester links the absence of young trees caused by browsing pressure to a lack of time: climate change increases the urgency of regeneration, yet young trees are missing because they have been browsed down over decades. This normative assessment is grounded in

a projection of possibility: if older trees continue to die under these conditions, “there will really be a problem.” Game browsing thus gains particular significance in the context of climate change.

The discussion of browsing highlights not only the absence of young trees but also the practical processes of anthropogenic intervention:

> If you look here, there’s a side flank. […] We have beautiful regeneration, especially in the upper part. But the small ones. Or those above the browsing level, but nothing in between. Everything has been completely eaten. For me as a forest manager, this means that if I give the forest light so that regeneration can occur, the regeneration should be able to grow. It doesn’t. Because the pressure from game is simply too high. […] Then you don’t actually have the next generation, or you have it later. That means you lose a decade or two, or whatever. And the old stock is also getting older. And by opening up the forest and maintaining it, you actually want to initiate regeneration so that it can grow again. Then your goal would be to carry out the next intervention in 25 years. You would be able to take something out again in favour of what has grown over the last 20 years. If everything grows normally, you will have trees 4-5 metres high again after 20 years (Interview “Forester 7(1)”, February 2023).

Here again, a forester describes interventions planned with long-term forest dynamics in mind. This approach draws on succession theory and the assumption that high levels of diversity contribute to resilience. Practically, this involves removing older trees to create light conditions favourable for younger cohorts expected to form the forest of the future.

Figure 13: Browsing damage to a deciduous tree, as shown on a forest district website (Source: Forst Aletsch, [no date]).

However, this cycle is disrupted by wildlife, which prevents young trees from establishing. In other words, wildlife constrains the regeneration process. The carefully structured interventions undertaken by foresters are effectively nullified by browsing pressure. The causal force of wildlife thus counteracts that of human forestry interventions.

This causal interaction between wildlife and human practice is further illustrated in the following statements:

> We actually do everything by textbook. Even the experts say we're doing everything right. But if you don't achieve the expected results with your interventions, then you have a problem somewhere. [...] In a huge regeneration area that has been opened up again and again, either nothing happens at all or it doesn't happen the way you want it to. Even though everything has been proven to be correct from a technical point of view. And so, by process of elimination, you can say: the problem clearly lies with the game (Interview "Government employee 5 (federal)", February 2025).

> The game is decisive in determining whether the measures we have been taking for 20 years are successful or not. From nature itself and from our interventions, you can see that it is working. Ultimately, the game decides whether it works or not (Interview "Forester 5", February 2023).

> Personally, I just feel that the game population needs to decline even further to make the forests truly fit for the climate. This will allow deciduous trees to establish themselves across large areas. Otherwise, you'll just end up with areas where you can't achieve this. It's simply not possible. The tree species you need to grow now are, for heaven's sake, the ones that game likes to eat best (Interview "Forester 10", October 2023).

> We have no possibility to plant anything. [...] I've tried it myself. I've always done things like that. [...] It doesn't work, no results. [...] But the problem is always the wildlife. Even if something grows, it gets eaten straight away. So, I don't get any results (Interview "Forester 3", September 2022).

All of these accounts share a common theme: wildlife is described as a causal force that resists and cancels out the effects of human practice. Outcomes that might otherwise be expected from interventions—such as planting, thinning, or creating canopy openings—remain absent. Wildlife therefore limits the forester's field of practical possibilities ("we have no possibility," "it's simply not possible") to intervene effectively in a changing forest. In this sense, wildlife renders certain forms of human-assisted adaptation practically impossible.

While tree planting and invasive species are topics marked by considerable uncertainty, the case of wildlife browsing appears far clearer: there is a direct causal link between browsing and the suppression of climate-adapted species, which is widely recognised and rarely contested, and the current state—intensive browsing—stands in stark contrast to the desired state of successful regeneration. The problem is therefore unambiguously defined.

Yet this certainty must be understood within the broader uncertainty surrounding forest adaptation. Because adaptation under changing climatic conditions is expected to rely heavily on natural regeneration and the promotion of diversity, the reduction—or absence—of browsing becomes

essential. Consequently, most foresters converge on a similar conclusion: wildlife populations must be reduced to levels that no longer constrain regeneration.

The issue of wildlife thus illustrates—unlike the cases of planting or non-native species—that practical certainty does exist in the context of FACC in Valais. However, implementing this certainty lies beyond the direct control of foresters and therefore remains within the realm of the possible. Hunting and wildlife management fall under the responsibility of hunters and gamekeepers and are regulated at cantonal and national levels in Switzerland. I return to this issue in Chapter 8, where the socio-political dimensions of FACC are examined and practical contradictions are shown to translate into political negotiation.

The practical contradictions presented in Section 7.2 can be summarised as follows: planting seeks to expand the boundaries of what is practically possible while simultaneously confronting those very limits in biophysical nature. The example of non-native species such as Robinia raises the opposite issue: although its spread is constrained by practical measures, its biological properties may expand what is practically achievable under climate change. By contrast, the wildlife issue appears comparatively clear-cut: browsing negates foresters' interventions and restricts what is practically possible. Yet the logical consequence of this clarity—a reduction in wildlife populations—remains beyond the authority of individual foresters, leaving practice suspended within the realm of possibility.

Ultimately, the practices discussed here reveal a continual opening and closing of spaces of possibility. These spaces emerge through the interaction between biophysical causal forces, the knowledge through which they are interpreted, and the normative goals that guide practical action. In the following section, I shift focus from specific challenges in forestry practice to the practitioners themselves, examining how foresters understand their role as agents of change—particularly in relation to what must be done and what is possible to do.

7.3 The self in a changing world

In this section, I focus less on concrete moments of practice in forest adaptation to climate change in Valais and instead examine moments of inward-looking reflection—that is, how the acting self, understood as the individual subject and source of causal agency, refers to itself in the context of uncertainty and complexity. I begin by considering how this self is articulated in relation to two key themes encountered so far: time and the transcendence of nature (Section 7.3.1). I then turn to how the acting self is conceived in relation to the openness of the future (Section 7.3.2). The subsequent section (Section 7.3.3) addresses the emotions invoked in the context of this uncertain and open future. Finally, Section 7.3.4 explores how, under these conditions, a necessity to continue nevertheless emerges.

7.3.1 Temporality, the self, and transcendental nature

A recurring theme in the previous sections is the temporal dimension that consistently shapes the context of FACC. As already noted, foresters must think several decades ahead when taking action. In flatter, more accessible areas, the interval between interventions is typically around 20 to 25 years, whereas in steep mountainous terrain it may be twice as long, as the following forester explains:

> In mountain forests, we have a rotation period of 40 to 50 years: You do one intervention now and then you can't do anything for 40 years. Those are actually the scenarios. So, when the next forester comes to intervene, the change is actually already there in terms of the climatic situation. But the trees are not there (Interview "Forester 1", September 2022).

This quote illustrates how three temporalities come into tension: the pace of climate change, the forest's capacity to adapt, and the forester's ability to intervene. At the concrete, time-bound moment of intervention, the forester confronts a discrepancy between a rapidly changing climate and the forest's slow adaptability. In practical terms, this manifests as the presence of certain climatic conditions ("change is already there") alongside the absence of trees adapted to them ("trees are not there"). The forester thus faces a fait accompli—an already determined situation—in which his capacity to act appears almost insignificant.

This sense of insignificance is also evident in the following quote, where the forester refers to the lack of regeneration caused by browsing pressure from wildlife:

> Our trees are 250, 300 years old. When I've been a forester for 35 years, I'm just a tiny little squirt [*hüera kleines Würstchen*] who can have some influence. Now we simply have a layer missing from 0 to 80 years. That's quite remarkable. You can't catch up with that. You can only catch up with that in 80 years. […] Then one day there'll be a crash here. You can't fix it tomorrow. You can't just take off a wheel like on a car, put a new one on and carry on. You can't quickly change a wheel. You can't do that with a forest (Interview "Forester 4", February 2023).

Here again, multiple timescales collide: the age of existing trees, the absence of a regeneration layer spanning 0–80 years, and the duration of a forester's working life. By comparison, the forester's professional lifespan appears brief. The self and its interventions seem ephemeral. Yet from a human perspective, 35 years is of course a considerable period—one during which countless trees are felled, young trees supported, and numerous measures implemented to prepare the forest for future conditions. Viewed against the extended temporality of the forest, however, such efforts may amount to little more than changing a car's wheel: the forest remains neither roadworthy nor fully adapted to climate change.

From this perspective, one's capacity to act appears diminished—as the forester himself acknowledges ("I am a tiny little squirt"). This insignificance stems from a reflexive recognition that higher forces are at work—forces that transcend the embodied agency of the forester.

Yet the challenge lies not only in divergent temporalities and the transcendence of natural processes, but also in their interaction with the openness of the future. In the following quote, a forester refers to the long-observed decline of pine trees (see Section 6.2.2):

> We were very fortunate that the pine trees died off over a period of 40 years. During those 40 years, either we or nature managed to restore a population that could take over this protective function. The forest became increasingly sparse. Regeneration followed. This meant that the transition could largely be achieved naturally. [...] But now the question arises: which scenario applies to you? With the pine trees, we had 40 years. If we also have 40-50 years with the spruce and larch trees, if it goes slowly, we can [...] bridge the gap with natural measures. In other words, with forest management, targeted forest management. But if it all happens at once in 10 years—which no one knows—then we will probably all be overwhelmed. We will be overwhelmed by the speed at which it happens (Interview "Forester 5", February 2023).

The forester extrapolates past experience with pine dieback to other species and future climatic conditions. This reveals the interplay between causal forces (e.g., spruce and larch may decline as pine has) and the openness of the future (e.g., the pace of this process remains unknown), together generating a field of possibilities. Crucially, the issue is not merely whether spruce and larch will die within 10 or 50 years, but whether the forester himself will be overwhelmed. From the standpoint of the present, a form of ignorance emerges—a lack of clarity about whether the potential for action still exists. In this sense, the field of practical possibilities appears to narrow. It is precisely this prospect of being overtaken by the pace of natural processes—and thus by transcendence itself—that renders one's own causal power seemingly insignificant.

These extended temporal horizons and the transcendence of nature also reinforce the rationale that forestry should increasingly be guided by natural processes—that is, by these very transcendental forces (see also Section 7.1.2):

> For me, I don't see a miracle tree right now. What tree is going to save our forests? Which one? No, nature does things pretty well, I mean. It will try to adapt to what is happening. What we have here has been working for maybe thousands of years now. There have certainly been fluctuations over the years (Interview "Forester 8", March 2023).

This quote raises the question of whether any particular tree species can fulfil the forest's protective function—and whether it should therefore be actively promoted. The forester, however, rejects the notion that a single species possesses such "magical" properties. Instead, it is nature as a whole that holds the capacity to adapt. Collaborating with these forces thus appears logical, especially if such cooperation with transcendental nature has been disrupted in recent decades.

Yet this was not always the case:

> Well, if you look at how our ancestors worked: They had [...] a lot of private forest. And they always looked to this forest. They passed this down from generation to generation. And then the grandfather came and said, "You can cut down that tree because it's big enough, because my grandfather planted it back then." Just things like that. Of course, these are things that are really lost today because the connection is simply missing. If

> you're no longer integrated into these processes, you have no idea what's going on here. And in the past, they had to do it because it was their livelihood, in a sense. It was simply part of their existence, of being able to live here in this environment. And that's been lost now. That's just—how should I put it?—the fault of industrialisation, to a certain extent. That you're losing your connection to nature more and more (Interview "Forester 7(2)", October 2024).

According to this account, the role of the forester was historically shaped by a close relationship with nature. This connection was especially evident in temporal terms—here with reference to the human realm: knowledge was transmitted across generations, accompanied by confidence in its durability. Such transmission was not merely optional; it was essential for survival in the harsh conditions of the mountains. According to the forester, this connection to nature was disrupted by modern industrialisation, and the present challenge is to rediscover it.

Taken together, the quotations discussed in this section suggest that the accelerating pace of climate change, when contrasted with the long temporalities of forest processes, generates a sense of personal insignificance and decentring, alongside an awareness of the transcendental forces at play. In encountering this other—nature—the individual self appears to lose its centrality, recognising its inability to control the natural world. Its agentive power becomes only one force among many powerful and often unknowable dynamics of biophysical nature.

Temporality in the context of FACC is therefore deeply intertwined with the formation of the anthropogenic subject as a causal agent; it is far more than a superficial interaction of different timescales. At the same time, the transcendence of nature serves to legitimise particular strategic and practical responses—that is, specific modes of activating human agency—which I explore in the next section.

7.3.2 "Anything is possible": Trial-and-error in the absence of results

The previous section showed that, within the long timescales of forestry, the acting self can appear to dissolve when positioned in relation to the transcendental powers of biophysical nature. Yet, from the perspective of the axiological imperative (see Section 3.2.3), the subject is always already acting and must therefore orient itself along certain normative axes. Accordingly, it is less meaningful to ask whether a subject can act in the face of transcendental powers and long-term natural processes than to ask what it actually does and which general principles guide such practice. As a first step toward exploring these questions, it is helpful to consider what forestry practice under climate change no longer entails:

> You can't just open any book and say, "Let's do this now." We learned silviculture in the 1980s. You went into the forest and were told, "This is what the forest should look like. This is the forest community. We maintain it this way and that way. And in 100 years, it will be a thick forest." You can't do that anymore (Interview "Forester 7(1)", February 2023).

This quote clearly shows that climate change has rendered reliance on tried-and-tested practices impossible. In the past, foresters could refer to textbooks that provided general guidelines for intervening in the forest. This made decisions—and the reasoning behind them—far more straightforward, reinforcing the forester's role as someone who gets things done. Paradoxically, climate change and the multiplicity of possibilities it introduces expand the forester's decision-making authority and agency, as he must now choose which path to follow.

However, decision-making itself has not become any easier, as the same forester notes:

> We have to accept change. What we decide today for tomorrow may no longer be valid the day after tomorrow. Maybe the day after tomorrow we'll be importing trees from Turkey, or who knows what. Of course, anything is possible. We can't say for sure (Interview "Forester 7(1)", February 2023).

This quote reveals the reciprocal relationship between the necessity of change ("we have to accept change") and practical decision-making. It is not simply the case that the forester gains more practical possibilities because the space of the possible has expanded. At the moment of decision, he may indeed face a broader range of options, but once one possibility is selected and enacted, it may quickly lose its validity and require further adjustment. The role of the forester is therefore characterised by a continuous dialectic—a cycle between the opening and closing of a field of possibilities.

How, then, under conditions in which "anything is possible," does a forester justify the specific measures he nevertheless takes—and is obliged to take? On what grounds are such decisions made? Insight may be gained by examining a concrete example. The following quote describes a measure implemented to combat severe browsing damage to climate-adapted deciduous species such as birch or aspen (*Populus tremula*) by wild animals:

> Changes only occur if you create a regeneration gap, and then birch trees will grow there, as a rule, [and] aspen. […] If you cut large gaps, they grow so lush that the game is unable to eat everything. […] And then we've been doing individual protection for years. I do that on the side. I can't bill it anywhere, so we have to pay for it ourselves. […] It works well with birch trees. They grow about 40 centimetres a year. If you do that for three years in a row, they're gone. That's the kind of thing we try there (Interview "Forester 3", September 2022).

In this case, "individual protection" refers, as the forester further explains, to sending employees into the forest to smear a bitter-tasting paste on the tops of young trees to deter animals. Other foresters use sheep's wool or install fencing—either around individual trees or across entire areas. These measures are resource-intensive, particularly in terms of human labour, and costly; as the quote indicates, they are rarely reimbursed by higher political authorities (e.g. the cantonal administration). Precisely because these costs are often borne locally, strong justification for such actions is required.

In the quote above, the justification lies in the fact that these measures “work well” and that “changes occur.” It is the observed effect—the result—that validates the action. Yet this result becomes visible only because it can be measured within a limited timeframe (in this case, three years). Even so, this strategy was arrived at only through experimentation.

Accordingly, the absence of conventional, well-established practices legitimises the use of trial and error as a strategy for forestry under climate change. As discussed in Section 7.2.1, this approach is particularly evident in the testing of new and non-native tree species. It is not merely a matter of choosing to experiment; foresters are compelled to do so. This necessity is evident in the following quote, where a forester discusses one of his test plantings:

> At some point, you have to start somewhere. That’s my motto. And now we have a certain range of trees to choose from. I think you can do something with ten to twelve tree species. But if you expand that further, with ten provenances from each tree species and then 20 new tree species from Africa and South America, it becomes endless. Because every test you do, you lose five years. […] Because you have zero experience. The holm oak is a good example. And from my point of view, you couldn’t have known beforehand how it would react. You have to try it. But that was seven years ago, and in those seven years we haven't made any progress (Interview “Forester 1”, September 2022).

The forester conducted test plantings with 10–12 different tree species, including the holm oak (*Quercus ilex*), a Mediterranean evergreen oak. As he explains, this species did not fare well during the cold winters still typical of Valais: unlike native deciduous trees, it retains its leaves through winter, which then freeze.

The forester could not have known this outcome in advance. In this sense, the trial planting was justified. He gained knowledge from the experience—even the absence of a positive result is itself a result. Yet he still feels that no real progress has been made, likely because uncertainty persists regarding which tree species should be promoted in the future. Despite these trials, he remains in a state of not-knowing. Moreover, he now questions whether it makes sense to continue testing new species or provenances at all—a hesitation shaped by the time pressure under which decisions must be made.

The limitation of the trial-and-error strategy lies in the absence of long-term experience or verified knowledge. But is this a reason to abandon the effort altogether? Not at all, as another forester makes clear:

> It’s perhaps a bit of a trial-and-error thing. And for forest management, it’s a complete change. Because you’re used to long processes and working with nature. And now you have to bring in other things [trees] in some cases. We have to try something now. Only our successors will [see] whether it will be successful in the end (Interview “Forester 10”, October 2023).

Given the long timeframes involved, the forester explicitly acknowledges that the results of his trials will not become empirically visible within his working life. Accordingly, he cannot learn from

them directly. And yet he must still act ("we have to try something"), because no viable alternative exists.

The rationale for trial and error thus does not arise solely from the desire to generate new knowledge, but from the simple fact that inaction is itself a form of experimentation. In the absence of experience-based guidance, experimentation becomes a necessity. In a world in which anything is possible, the forester's actions unfold within the logic of trial and error. Forestry work is therefore marked by continual testing, the results of which—whether success or failure—may become visible only after many years or even decades.

At the same time, this trial-and-error approach is inherently characterised by the possibility of absence. The individual forester mobilises their causal power in an attempt to intervene in natural mechanisms through targeted action, motivated by the desire to produce a specific and immediate outcome. Yet, given the openness of the changing world and the limits of understanding, that outcome may fail to materialise. Nature may nullify the intervention, as if nothing had been done. Alternatively, the result may exist but remain unrecognised because it is not (yet) actual.

As the quotes above illustrate, foresters are aware of this potential absence of results: they recognise that the intended outcome may not occur—or that, even if it does, they may never witness it. The forester's role under climate change is therefore defined not only in relation to what exists and is known, but also through absences and the knowledge and reflection surrounding them.

7.3.3 Feeling powerless, depressed, and defeated?

The present section examines in greater depth the absences that foresters encounter in their practice under climate change. In the following quote, Forester 7 reflects on cases in which the desired results of an action fail to materialise:

> [We] will certainly try more and more to plant sessile oak seeds and see if anything comes of it. With perhaps moderate or perhaps good success. We don't know that either. And now we will see how we can learn what works and what doesn't. Maybe you do this crazy thing and the next time you try, it works, and then you have to see why it worked and why it didn't work last time. […] For us, it's just extremely depressing when you try to do something and then you go back to check after maybe five years. After five years, nature should have come to terms with the situation, I would say. And then you should already be seeing some things growing again. And you do see it! When you have little trees that are still in the snow when the game is around, they are still protected, but as soon as they get bigger, they are simply knocked out. And that's really annoying. It's just really depressing when you go in there afterwards and say, "Damn it, we did something 15 years ago—that's half the rotation period—and now we still have nothing." Maybe it's not just the game, maybe there's some other problem too. But the game is certainly one of the reasons why it hasn't grown. And then you just have to say, "Goddamn again" (Interview "Forester 7(2)", October 2024).

The forester refers to practices aimed at establishing climate-adapted young trees in the forest. In addition to the sowing mentioned in the quote, this likely includes logging intended to increase

light penetration and thereby promote regeneration. At the moment of implementation, these practices are characterised by trial and error and, consequently, by uncertainty regarding their outcomes. Nevertheless, they are driven by a concrete goal—that these labour-intensive efforts will produce tangible results. The forester thus identifies a practical opportunity and, based on the knowledge available to him, intervenes in the world in a manner he considers justified.

However, the forester is describing the moment when, after a certain period, the intervention is evaluated and the desired outcome has not been achieved. The result of his action is therefore "nothing"; several years have effectively been "lost." This absence is inherently shaped by the temporal structure of action: although it becomes visible at a specific moment, it forms part of a much longer process (15 years or more, as he notes). Anthropogenic causal powers, deployed with expected natural dynamics in mind, were ultimately negated by other, unaccounted-for forces—primarily wildlife.

These absences themselves exert causal force. It is "annoying" and "depressing" for the forester to observe that, despite his intervention, "nothing" is growing—not even a single sapling. Simultaneously, he expresses anger ("Goddamn") because the outcome might have been different were it not for wild animals. This insight emerges through the contrast between the presence of small, snow-covered trees and the absence of larger ones. Wildlife makes it virtually impossible to test alternative strategies—error is, in a sense, preconfigured.

The following quotes illustrate what absent consequences—or their anticipation—can trigger before or at the moment an action is undertaken:

> It is concerning to hear that there will be sessile oak stands here in 50 years. From a forestry perspective, one has to ask oneself: "Do I even want to do anything?" I mean, the gaps will appear either way. [*laughs*] Why should we create additional gaps? (Interview "Forester 11", October 2024).

> With the measures we have introduced [so far], I was convinced that we could actually achieve quite a lot with the limited funds available. At the moment, with climate change, everything is being called into question. Even the entire management system is being questioned. On the one hand, we are managing the forest for regeneration and biodiversity in order to initiate this process. On the other hand, you could say: "If everything is going to be destroyed anyway, what's the point? Does it still make sense?" (Interview "Forester 5", February 2023).

Both quotes raise rhetorical questions about the usefulness of specific actions, implicitly suggesting that these actions may no longer make sense. Accordingly, they appear unjustified and perhaps should not be carried out. Transcendental processes in nature ("in 50 years, there will only be sessile oak stands here"; "everything is being called into question") provoke a fundamental questioning of the necessity of activating one's own agency. In these cases, the causal power of absence manifests less as anger or depression than as a sense of defeat.

It is important to note, however, that this sense of transcendence and the absence of meaning are articulated through conditional statements: only if these transcendental developments occur will defeat follow. Even if their occurrence appears likely, they remain within the realm of the possible—and this is precisely the decisive point.

It is not the absolute absence of meaning or results that drives these reflections. Otherwise, the actions would never have been contemplated. Rather, these reflections arise from the possibility of absent outcomes, whose causal power emerges in the form of questions. If only certainties existed and possibilities were excluded, the absence of action and meaning would be expressed as fact rather than as inquiry—or might remain unspoken because it would be self-evident.

These rhetorical questions also reveal that foresters are engaged in dialogue with themselves. Although the statements emerged in interviews, it is reasonable to assume that such questions are also posed privately, constituting forms of "internal conversation" (Archer, 2003). This dialogue is possible precisely because the situation is not clear-cut but demands questions whose answers are not known in advance. Feelings of uncertainty and powerlessness are therefore themselves only possible states—never fully settled. There is always a counterpart.

This counterpart becomes visible in the following quote:

> That's quite a challenge. If you look at the time frame you have available and what you actually need to do, then you have to say, "That's an impossible task". If nature won't be able to help itself, then we're going to have a problem (Interview "Forester 10", October 2023).

The quote speaks to what is not possible: implementing sufficient adaptation measures within the given timeframe. The forester refers here to a practical or normative impossibility—what he or his team can achieve through their embodied causal power. Yet this impossibility is qualified by an epistemological condition ("if you look at the time frame"). It is therefore not absolute but conditional, leaving open the possibility that circumstances might unfold differently. The second assertion ("we're going to have a problem") is likewise conditional ("if nature cannot help itself"). Here, the condition lies within the natural world, while the consequence is normative-practical ("we"). The scope of possible action is thus shaped by external, potentially uncontrollable forces.

The following statement can also be understood within this dialectic of possibility: "In a sense, it's exciting, but it's also depressing when you look at what's going on" (Interview "Forester 7(1)", February 2023). As an external observer of a changing world, the situation appears exciting; as an active participant within it, it becomes depressing. Foresters thus navigate transformation by adopting multiple perspectives and allowing them to enter into dialogue.

Accordingly, this section has shown that the self is referred to not only as a causal force within a socio-ecological system but also as an emotional subject. These emotions may appear

contradictory, yet they frequently take the form of depression, powerlessness, and defeat. However, as the next section will demonstrate, giving up—or doing nothing—is not an option.

7.3.4 "And then it goes on": The necessity to cope with change

As an entry point to this section, I begin with the conclusion of a 2015 report on forests and climate change in Valais, to which I have referred repeatedly throughout this thesis:

> Even though we think we know more and more about climate change, there are still many unknowns in individual areas. The forest is a complex ecosystem and it is difficult to predict what the ideal forest will look like in 2050 or 2100, one that is able to cope with climate change. The only sensible and pragmatic approach today is to focus on an ideal mix of native and sites-specific species in forestry, while always ensuring a good mix of ages and a balance with wildlife (Métral, 2015:20).

This conclusion succinctly summarises the insights of this chapter gained so far. By referring to the complexity of the forest in the context of climate change and to the uncertainty that accompanies it, a specific approach to forestry is established: the forest should be mixed in terms of tree species and age. According to the quote, this complexity and uncertainty appear to leave no practical alternative. This approach, described as "pragmatic," thus sets a clear direction so that the "ideal" forest can still be pursued. Even if absolute control over nature is not possible—given its complexity and our uncertain knowledge of it—the ideal itself remains defined and can be practically oriented toward.

In doing so, foresters refer to practical certainties that arise precisely from the current situation of change and uncertainty:

> You have to learn to deal with this change. That's the first thing. We have no choice. You have to learn from it, what's good and what's bad. […] After all, we don't know whether—it doesn't matter which tree species I mention—walnut, ash or lime trees will still be viable in 50 years' time. We really don't know. Because it has all happened so quickly. But you cannot say that because we don't know what will happen, we won't do anything. That would be the worst thing we could do (Interview "Forester 7(2)", October 2024).

> Yes, it's just difficult… No one can pull the right answer out of a hat or shake it out of a bottle [*aus dem Ärmel zaubern oder schütteln*]. That's not possible. *[laughs]* I say: you still have to try a little bit to understand nature. […] I mean, climate change is showing us the direction. The direction it's going to take. And yes, we just have to try to work in that direction now. At whatever pace. But we certainly can't just stubbornly look away. We definitely can't do that (Interview "Forester 11", October 2024).

Despite the many possibilities and the openness of the world—manifested in uncertainty about which tree species will survive or in the absence of a single correct answer—certain necessities emerge in the form of impossibilities: one has "no choice," one "cannot say" that one will do nothing, one "cannot stubbornly look away." These forms of determinacy are thus articulated through negation.

Translated into positive terms, such necessities mean that one "has to learn to deal with change" or "has to try to understand nature" and work with it. In both negative and positive expressions, the emphasis falls on "one" or "we" (in German often *man*). What is being referred to here are therefore practical necessities of the acting subject.

Forester 7 explains in more detail how this practical necessity relates to changes in the biophysical world:

> You have to develop a certain pragmatic approach so that you can let things run their course. Otherwise, you'll ruin everything. You can't always feel that the measures you're trying now will be successful. [...] And then it goes on. And then there's another problem, which is solved with a new solution, so that things can continue. These are always issues... I told you before, it's not going to be the case that nature collapses. [*His previous words:* Nature will take care of it. That's not the problem. That's not the problem. The question is whether we can handle it.] That won't happen. It will certainly continue somewhere (Interview "Forester 7(2)", October 2024).

This quote begins with the practical necessity of developing a pragmatic approach. Yet already in the second part of the sentence, reference is made to something else: an undefined "it." This vague "it" is carried forward in a series of affirmative statements: "Then it goes on," "it will surely continue somewhere."

A clue to what this "it" signifies can be found in the reference to "nature." Earlier in this chapter, I showed how nature is invoked as a kind of guideline or yardstick for human action. At first glance, a dichotomy seems to be drawn between nature—organisms, species, ecosystems—which is changing, and humans, who experience problems as a result of this change. Yet the statement "nature will take care of it" complicates this dichotomy. It suggests that this "it" is something other than nature itself.

This "it" therefore appears to transcend both the individual actor and the entirety of humanity and ecological nature. It should thus not be understood as marking a difference between these categories, but rather as a dialectical sublation of such differences into a form of identity. "It" is what is, and what is, is "it." One might therefore interpret it as the unstoppable flow of the world. The forester refers here to something that transcends him, yet of which he is ultimately a part. "It" remains undefined precisely because it gestures toward what, from a dialectical critical realist perspective, might be called totality—the whole—something that resists differentiation. Ultimately, "it" shapes human action, since action itself forms part of this undifferentiated flow.

This introduces a somewhat different form of pragmatism from the one described in the report cited above. It is no longer a specific pragmatism that arises from uncertainty in order to achieve a predefined "ideal" forest. Instead, the ideal itself no longer appears absolutely determined; it becomes only one possibility. It may even be that humans no longer have a secure place within this system. Humans themselves become one possibility among others—one that may not remain actualised.

Accordingly, Section 7.3 ultimately reveals the constellational embeddedness of humans within the biophysical world, where the self becomes inseparable from the world. At the same time, this implies nothing less than that human presence in any given place is not guaranteed. As shown throughout this section, the conception of acting subjects is shaped in relation to the transcendence of nature, intertwined with the temporal dynamics at play. The same applies to actual practices and their underlying strategy of trial and error in the face of the potential absence of results. In this light, expressions of powerlessness, depression, and defeatism become more than understandable.

Yet despite these profound constraints on the acting subject, practice remains possible—and is in fact exercised. On the one hand, this is because the biophysical world does not simply (pre)determine the actions of foresters but remains open: there is space for the practically possible. On the other hand, it is the flow of time, bringing change and allowing new things to emerge, that both demands and enables human practice. In light of this ongoing transformation, references to the practically possible are inseparably linked to references to the naturally possible.

7.4 Conclusion: The emergence of "muddling through"

In this chapter, I have focused on what makes practice possible in Valais forestry under climate change. I began by showing how the idea of human practice as both an intervention in and part of the world is linked to the concept of the cultural landscape—that is, the centuries-old mutual shaping of landscape and people in Valais. This justifies the pursuit of close-to-nature forestry, which translates into a practical strategy of managing forests through diversity. From the perspective of increasing resilience, it can be said that nature's range of possibilities for adapting to climate change-induced disturbances is thereby expanded.

In the same sense, practical attempts are made to push the boundaries of what is biophysically possible, for example through the planting of trees. However, these often remain attempts and trials, because such boundaries are not only pushed but also discovered; nature may undo the foresters' work, for instance through an unexpected heatwave. As the ambiguities surrounding non-native and invasive species demonstrate, such practices are likewise influenced by normative justifications and dilemmas, which in turn contribute to uncertainty. Conversely, the wildlife browsing problem reveals a practical-normative certainty: there is too much game, and therefore foresters argue that it must be reduced. Yet implementing this practice exceeds their immediate power to act and thus ultimately returns to the realm of the possible. Actors therefore refer not only to what could be different but also to the social structures that constrain such change.

I then examined how the self is referenced within this practical context and demonstrated how the profound temporality of the problem gives rise to a self that is related to, yet differentiated from, a force that transcends it. With this transcendence in mind, a strategy of trial and error emerges, within which the results of practice may remain absent—both in the biophysical world (as missing outcomes) and for the knowing subject (as absent knowledge of those outcomes). These absences can lead to expressions of powerlessness, defeatism, and even depression. Nevertheless, giving up is not an option, as there is certainty that "it" will continue.

In this sense, the role of the forester is perhaps no longer—if it ever was—to emancipate themselves from nature in an attempt to control it. Rather, forestry practice can be conceived, as Detten (2018:193, see also Detten, 2011) aptly described it, as an "intelligent muddling through": a mode of practice characterised by constant change—not only in the environment and in knowledge about it, but also in the normative ideals that structure future practice. With this muddling-through, contradictions and ambiguities inevitably arise as part of the process.

Yet this form of practice is not simply arbitrary or contingent. The notion of the "intelligent" points toward reason and goal-orientation, and the clearest expression of this structuring can perhaps be seen in foresters' reflections on their practice and their role in the world. This "internal conversation" (Archer, 2003)—reflexivity, or the relationship with oneself—is always linked to the relationship with the world: what is practically possible depends on what is possible in the world and, in turn, contributes to it. In this sense, I would therefore speak of a "reflexive muddling through" rather than an "intelligent" one.[56]

In addition to what I showed in Chapter 6—that this world of the possible is continually explored and rediscovered through a dialogue with nature—I have shown here that there is also a conversation with oneself. This self-dialogue, arising from the axiological moment, demonstrates that forestry practitioners always act with a certain degree of uncertainty. In this sense, forestry practice can be understood as shaped by axiological indeterminacy ("we must act, but we do not know what to do," Hartwig, 2007d:48), although this uncertainty is itself recognised and reflected upon.

Hence, it is not the case that foresters act in the absence of knowledge; rather, they know their own position—and its limits and possibilities—within this complex world quite well. It is also this moment of acknowledging and defining oneself in relation to a transcendental nature that emphasises the containment of the acting subject within the natural world. From this perspective, close-to-nature forestry may be understood precisely as a constant reflection upon the

[56] I find this concept of intelligent or reflexive "muddling through" not only very appealing because it describes my observations of forest management in Valais, but also because it resonates with many other aspects of life (perhaps even life itself). First and foremost, I might mention writing a doctoral thesis, in which various approaches are tried out, discarded, and reconsidered. One is constantly oriented toward the future—toward the moment when the work can be submitted and defended—only to realise that this is not an end, but rather another moment of moving on.

situatedness of one's knowledge and causal power within a wider world, translating into a practical strategy of "muddling through".

Ultimately, I have interpreted individual forestry practice as a continuous and complex movement between the opening and closing of the possible. This possible does not arise solely from the causal power of one actor but always in relation to others—above all, biophysical causal forces. Accordingly, practice can be understood as a way of engaging with the contradictions that emerge as the self, as part of the world, seeks to maintain its place within a changing reality—how it belongs to the world and how the world, in turn, comes to be through the subject. In the next chapter, I shift the focus to contradictions between subjects, that is, to social relations.

Chapter 8: Negotiating ecological change: Social conditions of the possible forest

"The type of forests we know will soon no longer exist." This statement, made by the director of the Swiss Federal Office for the Environment (FOEN) during a press conference in spring 2023 (Office fédéral de l'environnement, 2023:2), encapsulates several of the insights discussed in the previous chapters: the forest, as a biophysical entity, is undergoing change, and the only thing that now seems certain is change itself. Practically, this implies that new strategies must be developed.

At the same time, the statement invokes a social *we* that—within the context of a federal press conference—makes clear that responding to these ecological changes is not merely the task of individual foresters but also concerns political authorities and, ultimately, Swiss society as a whole. Indeed, in the same speech, the director calls for action ("measures are indispensable", ibid.) and outlines the measures being taken at the political level by the Confederation and the cantons. The statement thus functions both as a diagnosis and as a political appeal.

Against this backdrop, this chapter examines the social conditions of knowledge and practice in forest adaptation to climate change (FACC) in Valais—that is, the social world into which individuals such as foresters are thrown. More concretely, I analyse how the space of the possible forest is simultaneously enabled and constrained through social relations (see Research Question 3 in Section 4.3.2). I understand this socio-political dimension of FACC as emerging through relations between individuals and groups; these relations shape decision-making at the socio-political level while also serving as arenas in which the direction of social agency is contested and negotiated. Conversely, it is through their embedding in these relations that the practices of individuals—such as foresters in Valais—take shape. Social structures thus stand in a dialectical relationship with individual agency (see Archer, 1995, 2003; Elder-Vass, 2010).

This relational social matrix cannot be directly observed empirically; it operates at a deeper level of the social world than those accessible through individual speech acts and other forms of action. Following Archer (2003), who conceptualises reflexivity as the modality of the relationship between agency and structure, I aim to retroduce these underlying conditions on the basis of three empirical access points in Valais that reveal moments in which individual actors must reflect upon their position in society. First, in Section 8.1, I examine differing positions—and in some cases political conflicts—regarding what nature should become in the future, what functions it should fulfil, and thus which futures are considered possible. In Section 8.2, I analyse the role and self-understanding of foresters and forestry as they emerge in relation to the society in which they are embedded, a process that is actualised in a search for legitimacy for their concerns. Finally, in Section 8.3, I turn to questions of time and temporality, showing how political guidelines and scientific practices generate a particular zeitgeist, or social order, for dealing with long temporal

horizons—one that tends to close down the space of the possible and thereby shape the practical possibilities available to individuals.

The empirical material for this chapter again includes interviews with individual actors. However, these actors now extend beyond foresters to the broader community of silviculture, including government officials and scientists involved in FACC. I understand each speaking actor as already embedded in a wider social context and therefore always speaking from within social relations. My analysis thus aims to reconstruct these relations and structures retroductively through their statements. Accordingly, foresters are approached less as isolated individuals and more as members of a social group—"the forestry sector."

In addition, this chapter draws more heavily on material that extends beyond individual voices, particularly documents that reflect socially sedimented structures. These sources serve not only—as in previous chapters—to complement and contextualise interview statements but also to contrast with and challenge them.

8.1 Politicised natures: From wildlife to protective forests

In this section, I examine how certain aspects of FACC become politicised in the Valais case study. To this end, I discuss four themes in which differing positions—and at times explicit political struggles—emerge. The first concerns the issue of wildlife, where political positions are clearly polarised (Section 8.1.1). A similar, though less intense, debate can be observed in discussions surrounding the use and promotion of non-native tree species—primarily Robinia in Valais (Section 8.1.2).

I then contrast these cases with two areas in which no overt political controversy currently exists, yet where individual statements nonetheless reveal the potential for alternative interpretations and, consequently, for the emergence of political positions: first, the question of whether natural regeneration and biological diversity are sufficient for forest adaptation to climate change (Section 8.1.3); and second, the question of whether—and to what extent—protective forests can be maintained (Section 8.1.4).

8.1.1 Wildlife, hunting, and the politics of the future forest

The issue that most frequently provoked politically charged statements during my fieldwork was that of wildlife. As explained in Section 7.2.3, one of the most significant limitations on the practical measures foresters can take is the presence of wild animals in forests and their tendency to browse on the shoots of young trees—especially those species adapted to future climatic conditions. The high number of wild animals is therefore a thorn in the side of many foresters. For

example, during a public lecture, a forestry engineer remarked: “Eat a deer, save a tree” (field notes, 20 January 2023). Accordingly, foresters are making clear demands on hunters, gamekeepers, and, in particular, the politicians responsible for hunting policy, who set the culling quotas for red deer, chamois, ibex, and roe deer:

> You have to decide what’s more important. If, for heaven’s sake, regeneration is important, then the game simply has to be regulated (Interview “Forester 5”, February 2023).
>
> At some point, you simply have to reduce the population. It just has to be adapted to the biotope. That’s it. It’s simply a constant task of hunters [*von der Jagd*]. Now the mild winter has arrived again. This will cause mortality rates to drop significantly. So, few animals will die in winter. Of course, this means that the shooting plan will have to be increased significantly. Otherwise, we’ll have even more (Interview “Forester 4”, February 2023).

Viewed through the analytical lens developed in the previous two chapters—knowledge of and practice with nature—these statements reveal little sense of a field of multiple possibilities. Rather, they consist of clear causal chains (“this will cause,” “so, few animals will die,” the if-clause in the first quote, etc.) and practical necessities (especially the frequent use of “have to”). Regarding the social embedding of the two speaking foresters, however, a sense of possibility does emerge, because they do not refer to their own capacity to act (or that of their teams) but to that of other actors. These other actors are even directly addressed in the second quote: the hunters. According to the statement, the hunters have the power to reduce the game population but have not exercised it.

Accordingly, these references illustrate the relationship between foresters and hunters. It is articulated through the causal influence of game, which undermines the natural regeneration desired by foresters in the context of climate change. Consequently, foresters and forestry experts are attempting to persuade hunters to increase their culling. Ultimately, however, the cantonal authorities set the culling quotas: according to cantonal hunting statistics for 2020–2024 (see Kanton Wallis, [no date]b), the quota for the red deer population—identified in the interviews as primarily responsible for the high level of browsing damage—accounted for just under a third of the annual population of 5,000–6,000 animals in the canton. The aim of such a quota (which was also largely met) was to stabilise the population. Apparently, no reduction was sought during these years, even though there is talk of a “tense forest-game situation” in some cases (although this was the only reference to game browsing).

Accordingly, measures are being called for, particularly at the political level, and not only in Valais. In a joint position paper of August 2024, the Swiss Forestry Association, the Swiss Mountain Management Group, and two forest owner associations called for a reduction in the game population:

> The excessive influence of hoofed game (roe deer, red deer, chamois) in many forest areas slows down or prevents sufficient regeneration. This contradicts current forest and hunting legislation, which requires that the natural regeneration of tree species suitable for the location is ensured. […] The hoofed game populations and their spatial

> distribution must be quickly adjusted to be compatible with the forest. […] Urgent action is needed! (Schweizerische Gebirgswaldpflegegruppe et al., 2024).[57]

This statement should not be understood merely as an interview response but as a public declaration. It explicitly addresses other social actors with potential influence, namely the federal government and the cantons, which are responsible for setting shooting quotas. According to the position paper, a contradiction exists between the legal framework and its practical implementation. Here, too, the language of necessity appears ("must," "is needed"), but this also presupposes the possibility that the contradiction can be resolved if appropriate political measures are taken.

While this excerpt from the position paper demonstrates the political dimension of FACC, my focus is less on how the topic of game is debated politically and more on how this contradiction emerges and thus contributes to the possible forest itself. To this end, it is worth examining the situation on the ground in Valais and asking what actually prevents hunters from shooting more game—since it seems paradoxical that hunters would be unwilling to do so. The two foresters cited earlier illustrate this point:

> The problem with the forest and the game issue is that there has been no discussion or exchange of views for a long time. The foresters said, "We have too much damage caused by game." That's logical. We were able to prove it. The others [the hunters] bred game so they could shoot more during the hunt. That's a criticism, isn't it? The more game there is, the more they shoot, the better the hunt, the more interesting the hunt. Then they have a sense of achievement again (Interview "Forester 5", February 2023).

> Hunters want to shoot. Hunters want to go hunting, they want to get out and be successful. They don't care about anything else. Hunters don't know anything about the forest anyway. They just think that when they go for a walk in the forest, smoking a pipe and wearing a felt hat, they're experts on the forest. That's simply not true (Interview "Forester 4", February 2023).

These two foresters explain why hunters prefer a high game population: the more game there is in the forest, the more "interesting" the hunt becomes for them. Moreover, they shed light on the relationship between foresters and hunters. What stands out here is the dichotomy between these two groups: they refer to "they," and Forester 5 even calls the hunters simply "the others." This suggests that the relationship between the two groups is characterised by mutual opposition. Because the causal power of the hunters exceeds that of the foresters, the reduction of game remains undefined and therefore an unactualised possibility.

However, these groups—and especially their positions on hunting—may not be so clearly delineated. Some of the foresters I interviewed also hunt themselves (e.g. Forester 2, Forester 3), while others (such as Forester 6 and Forester 8) said that the issue of game was only a limited problem

[57] A similar position paper was written four years earlier by forestry experts from the research community (see Waldbau Schweiz, 2020). In addition, researchers repeatedly call for a reduction in the game population through other channels (e.g. Brang, 2017; Baumann, 2023), basing their arguments on various scientific studies on game browsing (e.g. Kupferschmid, 2022; Kupferschmid et al., 2015). Science is therefore also taking an explicit position here, which highlights the extent of the debate at a political level.

in their locations, although they did not oppose reducing the game population and recognised problems elsewhere.[58]

In addition, forestry stakeholders sometimes adopt the hunters' perspective in their attempt to explain the motivations for maintaining a high game population, as illustrated by the following cantonal employee (who otherwise agreed with the foresters quoted above and criticised high game pressure):

> Hunters sacrifice a lot of their free time. They pay for it too. Quite a lot, depending on the licence they take out and who you ask. But it is a relatively expensive hobby. Plus all the equipment you need. Well, it's a tradition in mountain cantons like this. People have been doing it for—I don't know—80 years. The father just goes hunting, so to speak. […] The husband is just away for three weeks. [And he goes] every evening for six months beforehand. It's accepted here. It's part of life. I don't question that in that sense. […] But of course that also means that they have certain expectations. […] They're usually groups. […] And now the expectation is that everyone in the group has to shoot a deer. Otherwise, it was a bad hunt. And it's very, very difficult to break away from that (Interview "Government employee 3(2) (cantonal)", February 2025).

Particularly revealing is how this quote illustrates that hunting in Valais is anchored in a sociocultural context. The current contradiction—namely that hunting is not practised in a way that meets the expectations of foresters and forestry experts—is explained through the "tradition" of hunting. The historically developed expectation of a successful hunt limits efforts to reduce the game population. From this perspective, the relationship between foresters and hunters reflects a clash between two groups rooted in deeper social structures. What the cantonal employee calls "tradition" seemingly transcends the agency of individual hunters and becomes a causal force in its own right that influences hunters' practices. At the same time, the structure is reproduced through these practices: traditions are passed down within families, and the high financial and time investments involved create a logic that demands a high return.

It is also revealing how the cantonal employee positions himself in relation to this tradition: he "does not question it" but appears to advocate "breaking away from it," even though such a break is described as "very, very difficult." This demonstrates that social change is not only negotiated between individuals or groups but can also create contradictions within individuals themselves. The presence of these social and individual contradictions, in turn, means that the forest of the future is associated with multiple possibilities, depending on how these contradictions are resolved.

Moreover, the issue of hunting is also linked to another highly debated topic in Valais and Switzerland:

[58] I also attempted to contact representatives from the hunting sector, particularly the cantonal department responsible for setting hunting quotas. Despite follow-up inquiries, my request for comment from the relevant authorities went unanswered—likely because I indicated that my interest in wildlife stemmed from the perspective of forest adaptation to climate change.

> At the end of the 18th century, they wiped out wolves and other large predators. That meant 200 years of humans living without predators. […] In that sense, wolves have nothing to do with my forest. […] [But] because of that, we now have forests that are like this [forests with bad regeneration] (Interview "Forester 4", February 2023).
>
> The biggest concern for Swiss forests at the moment is the red deer. And the red deer is linked to the wolf. Roe deer with lynx, red deer with wolf. It's pretty clear. You can now see that there is a balance between roe deer, lynx, hunters and the forest. It works. It doesn't work so well with red deer. Now people don't want wolves. Okay. [But] what do you do with the red deer? (Interview "Government employee 4 (federal)", December 2024).

These actors explain the continued abundance of game through the absence of their natural predators. Both interviewees emphasise predator–prey dynamics and causal relationships between species. According to the second quote, such a relationship exists between roe deer and lynx, which generally inhabit lower altitudes on the Swiss Plateau. There, the species coexist in relative equilibrium, and the damage caused by roe deer browsing remains manageable. In contrast, wolves are the natural predators of red deer, which currently cause the most damage to forests in Valais. Wolves were exterminated in large parts of the Alpine region over past centuries because they threatened livestock. In recent decades, however, the wolf population in Switzerland has increased significantly once again.

Wolf control has since become a highly contested and politically charged issue in Switzerland (see e.g. Schröder, 2024). Farmers in mountainous regions are calling for a drastic reduction in the wolf population due to increasing livestock losses, while conservation organisations argue that wolves are an essential part of the alpine ecosystem and should not be killed. In response to the sharp increase in both the wolf population (from around 50 individuals in 2018 to over 300 by 2023) and livestock attacks (from mostly fewer than 500 farm animals killed in earlier years to 900–1,800 in the years after 2020), the Swiss government decided at the end of 2023 to introduce stricter regulations on wolf control (shooting of around 125 individuals in autumn and winter 2024/2025) (Bundesamt für Umwelt BAFU, 2025).

The debate is thus highly charged, and the two interviewees indirectly refer to it in their statements. Although they do not explicitly take a position, it is evident that they regard the wolf as a factor that could facilitate forest adaptation to climate change. This reasoning reflects a causal chain: if wolves reduce red deer populations—and if hunting cannot achieve this to the same extent—while high deer numbers constrain natural regeneration, then wolves could contribute to the normative goal of climate-adapted forests through natural regeneration. Even though the interviewees do not explicitly call for more wolves—and this is likely avoided by forestry stakeholders due to the political sensitivity of the issue ("I'd rather not comment on that"; Forester 4, February 2023)—the rhetorical question at the end of the second quote becomes understandable: Why are wolves more strictly regulated than red deer?

Wolves, and the political measures regulating their population, thus represent another factor shaping the possible forest of the future. At the same time, the wolf debate also provides practical opportunities for forestry stakeholders, as the following example illustrates:

> We never comment publicly on wolves in Valais. At least not on behalf of forestry. Otherwise, we would be politically dead. That much is clear. […] But what I sometimes allow myself to say in discussions with hunters or farmers is that the wolves that are here eat our sheep in summer, which is a big problem. I can see that. But they also eat something during the rest of the year. I always say to the farmers: "Have you ever thought about why the wolves survive at all? They should be starving." Yes, because we have so much game now. That's because the game population has exploded and is far too high. Otherwise, you couldn't feed the wolves. In the hope that we'll get an ally on the side of agriculture. That the game population will be reduced a little (Interview "Government employee 3(2) (cantonal)", February 2025).

This example clearly shows how the wolf is used as a political strategy: the cantonal employee seeks to forge alliances with farmers to gain greater support for reducing game populations. In doing so, he attempts to strengthen the position of forestry within society and persuade hunters to increase their culling quotas.

The example of hunting and game browsing thus demonstrates that forest adaptation to climate change—and, by extension, the possible forest of the future—does not depend solely on the agency of foresters and forestry experts. Individuals in the forestry sector refer to the causal power of others (whose actions, in turn, depend on their own knowledge and normative goals), particularly hunters. This not only reveals another layer of complexity in FACC but also shows how mechanisms in biophysical nature (e.g. predator–prey dynamics) are interwoven with individual practices (e.g. hunting) and social structures (e.g. hunting traditions, historical path dependencies of wildlife populations).

In this context, the concerns of forestry are both transcended and constrained by social dynamics—such as the historical shaping of wildlife populations and the contemporary debate on wolves—and thus depend upon them. At the same time, social relationships open up a field of possibilities for actors within forestry: they attempt to influence others, which presupposes that change is possible. These sharp political arguments therefore arise because these actors understand the agency of others as unfixed and therefore open to alteration or resistance. Moreover, because the proposed solution is unambiguous, clearly comprehensible, and can be easily evaluated (an increase in shooting quotas linked to a reduction in game presence), it is also raised in a targeted manner.

8.1.2 "A special neophyte": The negotiation of Robinia across policy and practice

In principle, the political debate about wildlife and browsing concerns decisions about which aspects of nature (e.g. young trees, wild animals) should be promoted and preserved, and which

should be reduced or removed. A similar question of preservation and removal arises in relation to non-native and sometimes invasive tree species. As shown in Section 7.3.2, several practical paradoxes surround the management of *Robinia pseudoacacia*. In Switzerland, Robinia is classified as an invasive neophyte originating from North America and, according to government regulations, should therefore be controlled. At the same time, such control is often regarded as futile, as Robinia continues to spread. Finally, Robinia possesses characteristics that make it well suited to the future climate of Valais—particularly its drought tolerance—and it also provides effective protection against rockfall and erosion.

It is worth noting that Robinia is already widespread in the lower-lying areas of Valais (depending on exposure, up to over 1,200 metres above sea level). This extensive distribution is largely due to its historical use in railway and road construction for stabilising embankments and slopes (see Figure 14, p. 176). For instance, at least 41,000 Robinia trees were planted in Valais in the first half of the twentieth century for the construction and protection of the Lötschberg railway line between Bern and Brig (Bodenmüller, 1957). Robinia has therefore been present in Valais for some time and has spread widely during this period.

Figure 14: The author during field inspection of Robinia trees stabilising the slope beneath a railway line above Visp in Valais (Source: Photograph by Jueling Hu, 8 June 2023).

This historical path dependency means that foresters face practical contradictions when dealing with Robinia. On the one hand, they recognise that the species is not part of the native ecosystem and can harm it when Robinia trees become so dominant that they prevent other trees or plants from growing; on the other hand, they view the drought-resistant Robinia as a species capable of thriving in a future shaped by climate change and therefore do not actively combat it. This contradiction is usually resolved in favour of the second option (not combating it) on the part of forestry. One might assume that this could lead to conflicts with nature conservation organisations, similar to those between foresters and hunters.

In this regard, Pro Natura, a national nature conservation organisation, states on its website: "Planting trees from overseas carries risks. […] Pro Natura questions the planting and promotion of other species from overseas" (Pro Natura, [no date]). However, this issue does not appear to be a major concern in Valais, according to a representative of a local nature conservation organisation (Interview "Various 1", September 2022) and a representative of a nature reserve (Interview "Various 3", April 2023), as long as this tree species does not take over within protected and biodiversity-rich areas. Thus, there is no clear line of conflict between foresters and conservationists, as there is between foresters and hunters.

However, foresters refer to other key actors in the context of Robinia:

> Robinia is a special neophyte for us. Depending on which federal office we are communicating with, we are told: "You have to eliminate them." And then another federal office says: "Hold on to them, we might need them." […] So, when I submit a project for a rockfall protection net, it says: "We must first eliminate the Robinia trees on the perimeter where the rockfall protection net is to be installed, then you can build." But when we are reforesting, I always say: "Yes, it would be ideal if the Robinia trees were still there for safety reasons." And that's how we're currently approaching the solution: we don't cut down the trees, we go into the crown and cut the crown off. Then they don't react at the bottom. That means we have to cut the crown again every ten years, but we don't have such dense undergrowth at the bottom. And that's how we're trying to leave them in the stands so that they don't spread any further, but remain where they are (Interview "Forester 1", September 2022).

For this forester, the federal agencies are key actors to whom he attributes interpretative power regarding the management of Robinia. However, it seems problematic that federal agencies do not take a clear position on how to handle the species. The statements of various federal bodies appear to contradict one another.[59]

It thus seems that there is no consensus within the federal administration and that the correct approach to Robinia is still being negotiated. The forester is the one who must deal with this

[59] The forester is probably referring less to different federal offices than to two departments within the Federal Office for the Environment (FOEN): "Forest and Natural Hazards" on the one hand and "Biodiversity and Landscape" on the other. During my research, I heard several times—behind closed doors—that these two departments, or their representatives, do not agree on how to deal with non-native tree species.

contradiction, which further increases uncertainty and openness. This is evidenced, on the one hand, by the term "special neophyte": the handling of this neophyte is not clear-cut, but "special." On the other hand, the dialogical format referred to by the forester (one federal office says this, the other says that) also reflects the ambiguous situation.

At the same time, the forester resolves the above-mentioned contradiction in an almost dialectical manner: while various instructions come from the federal authorities, he pursues a practical synthesis by not completely eliminating the Robinia but by cutting back its crown every ten years. In doing so, the forester deviates from certain official requirements in practice and follows his own logic—an expression of his agency within this relationship, or even a form of resistance to official directives.

Another forester expresses a similar view regarding the handling of Robinia trees in nature reserves:

> The federal government and the canton, and therefore indirectly the Swiss population, want [name of a local nature reserve] to be free of neophytes. OK, that's the task we've been given. Whether it makes sense or not, or how much sense it makes, is for others to decide. We'll try to implement it afterwards, just for the sake of it. [...] Now, with all this maintenance of waterways and so on, they're still trying to combat Robinia a little bit, but certainly not by launching a huge campaign to eradicate it. I don't see that happening. But that's another decision that others have to make. Fortunately! And we'll implement it afterwards (Interview "Forester 5, February 2023").

In contrast to the previous example, there appears to be no contradiction within the authorities concerning the treatment of Robinia trees in nature reserves: they must be removed. It is also interesting to observe how the forester behaves in practice: he carries out the official requirements without resistance and even expresses relief that he does not have to make such decisions himself ("Fortunately!"). Thus, while the contradiction within the authorities in the first example opens up a space of possibilities—requiring the forester to adopt a practical position within it—in this case the space of practical possibilities appears closed to the forester. At first sight, he seems to have no causal power in shaping this social relationship but rather submits to political authority.

At the same time, however, several aspects of this example attest to the forester's agency. On the one hand, he explicitly accepts the decisions of the authorities, which at least presupposes the possibility that he could have refused to do so. Thus, even the absence of active agency implies its potential presence. On the other hand, he acknowledges that there are different ways of interpreting the Robinia issue, thereby subtly questioning the official guidelines. With statements such as "I don't see that happening," he also takes a position himself. Finally, in the same interview, he posed the rhetorical question, "Does it even make sense to fight [Robinia] anymore?" (see Section 7.2.2), which implies a stance against combating it.

In this sense, the space of practical possibilities is not completely closed from the forester's perspective. Rather, it emerges from the interaction between the individual power of the forester, that of the authorities, and the biophysical characteristics of Robinia—or, more precisely, from the structured relationship between them. On the one hand, the actual form of this relationship (the forester is obliged to carry out official requirements to combat Robinia) seems fixed and given; on the other hand, as the two quotes above suggest, it nevertheless allows for differing interpretations.

As we have seen, these differing interpretations also lead to divergent guidelines within the authorities themselves. For example, when I asked a cantonal employee about dealing with invasive species and mentioned Robinia, he told me the following:

> I would look at the Robinia separately [from other invasive species]. […] You absolutely have to fight tree of heaven or things like that. Japanese knotweed or things like that. They must not be allowed to grow. Really not. Get rid of them immediately. Robinia, pfff… I already have some of them [Robinia trees] in the protective forest. Above these villages […] we have areas with old pine trees that are very, very dry, where nothing grows anymore. We are really fighting for every tree there. And now some of the Robinia trees are growing in the adjacent areas. So we decided to cut branches with seeds and scatter them, hoping that Robinia trees will grow there. […] Either there will be another 200 metres of rockfall netting, to put it bluntly. Or maybe we can manage it with Robinia trees. Nothing else works anymore (Interview "Government employee 3(2) (cantonal)", February 2025).

Here, the cantonal employee compares Robinia with other invasive species such as tree of heaven (*Ailanthus altissima*) and Japanese knotweed (*Reynoutria japonica*), where the situation appears clear to him. While these species are eradicated aggressively, the cantonal employee is, paradoxically, supporting the spread of Robinia by distributing its seeds. His main concern is evidently the preservation of protective forests, which takes precedence over other considerations (e.g. biodiversity and nature conservation) and to which the causal properties of Robinia can contribute. In addition, the prior presence of Robinia in neighbouring areas seems to suggest that it can be further propagated; it is not an entirely new element but one that has already become established and proven its usefulness. Moreover, it acquires monetary value in comparison to rockfall nets.

While it should be emphasised that these are individual, small-scale measures, it again becomes clear that different actors hold different interpretations of biophysical elements—similar to the "game" issue. There are established interpretative positions (invasive and therefore detrimental to biodiversity versus drought-resistant and therefore beneficial for protective forests). However, unlike the case of wildlife and hunting, these divergent positions do not translate into the formation of distinct social groups or open political struggles. Rather, these positions cut across stakeholder categories (e.g. federal offices) and even across individual practitioners (e.g. when a forester must find a compromise or synthesis between opposing views). The long-standing

presence of this contradiction forces actors to engage with it. A degree of uncertainty arises precisely because these actors are aware of the different positions or, as in the case of the federal agencies, communicate both simultaneously.

8.1.3 When nature becomes political strategy: The promise of natural regeneration

In the previous two sections, I examined cases in which positions on the issue are clearly established and translate more (hunting) or less (Robinia) into negotiations between social groups. In the following two sections, I focus on cases where such positions are less firmly established—where one discursive position is clearly dominant and explicit, yet latent counter-positions are nevertheless discernible.

A prime example is the strategy of diversifying forest stands through natural regeneration. As shown in Section 7.1.3, this is the strategy that foresters actively pursue to adapt forests to climate change. At the same time, the concept of natural regeneration is also a key term dominating the political discourse on FACC. It is defined as "regeneration resulting from natural seeding or vegetative propagation," whereby regeneration itself refers to "the seeding and growth of young trees" (Bundesamt für Umwelt BAFU, 2021:56–57). The concept has become so ubiquitous in discussions of forest adaptation that most public documents employ it in a matter-of-fact manner.

For example, a national implementation guide for Sustainability and Performance Monitoring in the Protection Forest (German: *Nachhaltigkeit und Erfolgskontrolle im Schutzwald*, NaiS; see Frehner et al., 2024) describes the fundamental strategy for preserving protective forests under climate change as follows:

> In order to ensure that forests can continue to fulfil their protective function in the long term, sufficient, site-appropriate and sustainable regeneration is necessary. Light and heat conditions in the forest are largely determined by site conditions and influence the emergence of regeneration. Silvicultural measures in protective forests often aim to initiate or promote regeneration and promote stability. Because climate change is altering site conditions, natural forest regeneration adapted to future site conditions is particularly important: tree species that were previously dominant may no longer be present or may only be present in small numbers. At the same time, species from lower altitudes are spreading upwards. Depending on the altitude, it can take a long time for natural regeneration to take hold. This makes it all the more important to take appropriate silvicultural measures at an early stage so that the desired tree species can establish themselves and take over the protective function in the future. In addition to targeted regeneration measures, stand establishment and maintenance work will also become more important in the future. Even in the face of climate change, forests should be regenerated as naturally as possible. Natural regeneration is not only cost-effective, but also ensures genetic diversity. Planting should primarily be used as a supplement [...] (Frehner et al., 2024:16).

Almost every sentence in this excerpt contains the term regeneration. Natural regeneration is presented as a necessary condition for preserving protective forests. Several biophysical causal mechanisms are invoked (e.g., the influence of light and heat, or the successional movement of trees to higher altitudes), which serve to justify its promotion. These references form the normative basis for the claim that "forests should be regenerated as naturally as possible." Accordingly, natural regeneration becomes the focal point of practical measures, as seen in Section 7.1.3. It is thereby contrasted with tree planting: within this either–or logic, natural regeneration appears as the more cost- and resource-efficient solution. This point was also frequently raised in interviews when I asked about alternatives to natural regeneration.

Moreover, the idea of natural regeneration is closely linked to the concept of diversity. As one interviewee stated: "The first, second and third principles [of forest adaptation to climate change] are diversity. Tree species diversity, genetic diversity, structural diversity" (Interview "Government employee 4 (federal)", December 2024). The respondent refers directly to the five principles of forest adaptation to climate change developed by Brang et al. (2016:344–346), which in the same interview are described as the "bible" of forest adaptation. Alongside these three forms of diversity, the principles also include "increasing the resistance of individual trees to disturbances" and "reducing the rotation period or target diameter" (Brang et al., 2016:344–346).

Together, these measures aim to enhance forest resistance, resilience, and adaptability, thereby securing ecosystem services and reducing risk. As one scientist put it:

> We don't know what the future holds. First of all, in terms of climate. But that's only part of the story. […] There are other potential stress factors or difficulties when we think about ash trees and ash dieback. This is an introduced fungus that, within 20 years, has not wiped out ash trees across Europe, but has decimated them. […] This means that it could actually happen to any tree species. So even if we now say we are fully committed to downy oak, a natural tree species, a native tree species, well adapted to drought, which from today's perspective would certainly be or is the right decision. Then we would be well advised not to do this with downy oak alone, but to focus on different tree species in order to spread the risk. That is very, very important (Interview "Scientist 3", September 2022).

The scientist justifies the need for species diversity precisely through reference to uncertainty about the future. Since it is impossible to foresee which ecological mechanisms will become relevant (for instance, another fungal disease similar to ash dieback), a broad variety of tree species is considered necessary. The rationale behind the strategy of natural regeneration and diversity, then, is that scientific tools cannot structurally anticipate all contingencies in biophysical nature—or in knowledge of it. Within this logic, multiplicity is both the cause of the problem and its normative solution: because many things are possible under conditions of ecological change, as many responses as possible should be causally predisposed. Diversity thus becomes the synchronous—or time-independent—counterpart to temporal change and to the field of the possible forest.

Across these references, diversification through natural regeneration appears as the key pathway toward climate-adapted forests. However, I also encountered other voices in my interviews:

> At the moment, everyone is focusing on natural regeneration. This is also the federal government's primary legal objective. But if you want forests, if you want the ecosystem services that forests provide, this is probably not enough (Interview "Scientist 4", February 2023).

> This transformation [of the forest through natural regeneration] cannot be achieved across all areas. I don't believe that. It's simply too short a period of time, when you consider… Now they tend to think that it will be more like the extreme scenario […]. And you won't be able to achieve that. With moderate climate change, you could have said, "Yes, maybe, we could get there somehow." But if it goes in the direction of the most extreme scenario they have, you won't be able to do it. Then you have to hope that it doesn't immediately ruin the whole area when it happens. That the tree species will somehow manage it after all. And there will probably be problems on a small scale (Interview "Forester 10", October 2023).

Through a series of if-clauses, these stakeholders question whether natural regeneration alone can secure ecosystem functions—especially the protective function—across large areas under increasingly extreme climatic conditions. The possibility of drastic climate change, in particular, seems to undermine this expectation. Here, the scale of anticipated change appears to exceed the adaptive capacity attributed to natural diversity, especially in relation to the normative goal of preserving protective forests.

The crucial point in both quotations, however, is that natural regeneration is no longer framed as something simply given by nature. The reference is no longer purely naturalising—that is, it does not invoke only causal elements within biophysical processes. Instead, human actors ("everyone," "the federal government," "they," "you") are brought to the fore. Natural regeneration is thus stripped of its character as a self-evident or universal solution and becomes a socially and politically pursued strategy.

At the same time, the idea of natural regeneration is actively mobilised to emphasise concerns regarding wildlife management:

> The problem we actually have is the wildlife problem. We have regeneration, but it's growing slowly, really slowly. […] That's the limiting factor. And now… Actually, it was never a huge problem. But now that we have to say, "We need regeneration, right now!", it's becoming a problem (Interview "Forester 3", September 2022).

> Regeneration with tree species suited to the location is a legal requirement and a basic prerequisite for our protective forests. However, shrubs and young trees stand no chance against the dominance of wild animals. […] Our protective forests are facing extinction [*stehen vor dem Aus*]. Efforts in recent years to regenerate the forests […] have been in vain. Whether we manage to save the protective forests now depends on

political will (excerpt of the website of a local forest operation in Valais (Forst Aletsch, [no date])).[60]

In both references, natural regeneration is invoked as a fixed natural and legal requirement for forest adaptation. Yet this apparent stability is destabilised by browsing pressure: regeneration does not occur automatically but requires practical and political intervention.

These examples demonstrate that natural regeneration cannot be understood as merely "natural"; it also possesses a deeply social and political dimension. While the emphasis on nature suggests that ecosystems may help themselves—a "nature-based solution," so to speak—its realisation clearly depends on human agency, such as reducing game populations. Natural regeneration thus becomes an element that structures social and political relationships: it is simultaneously a scientific and official requirement for forestry practitioners and a rhetorical resource mobilised in struggles with other actors, particularly hunters.

The idea of natural regeneration therefore structures the discourse surrounding FACC. It appears to provide the causal mechanisms needed to adapt forests to a changing climate "naturally," and there is little epistemic doubt attached to it. It thus offers a seemingly clear strategy for practical implementation. Yet, as shown, natural regeneration itself belongs to the realm of the possible and may not constitute a sufficient condition for adaptation—for a variety of reasons, including excessive browsing, extreme temperature shifts, or other biophysical constraints. What ultimately underpins and structures the idea of natural regeneration is the normative imperative to preserve protective forests. I will return to this imperative in the next section.

8.1.4 The forest that must not fail: Rethinking the imperative of protection forests

As already mentioned, adapting forests to climate change in the mountainous region of Valais is particularly urgent because forests have long fulfilled a key social function: protecting infrastructure from mudslides, rockfalls, and avalanches. Without this protective capacity, it would have been virtually impossible over the past centuries to establish the dense network of settlements and transport routes that exists today—and which is likely to expand further in view of growing mountain tourism and population pressures. Moreover, it is widely assumed and scientifically demonstrated that the frequency of such hazard events will increase (see, e.g., Stoffel et al., 2024).

[60] This forestry operation refers to the following legal text: "The cantons regulate game populations in such a way that the preservation of the forest, in particular its natural regeneration with tree species appropriate to the location, is ensured without protective measures" (Bundesversammlung der Schweizerischen Eidgenossenschaft, 2025:Art. 27.2).

Accordingly, preserving this protective function is the primary goal of forest management, as the cantonal administration states on its website:

> No less than 87% of forests have an indispensable protective function that must be maintained against natural hazards. The aim of forestry interventions is to preserve the forest in a condition in which it can fulfil its protective function optimally and without interruption. However, the natural development of the forest also includes phases of decay (ageing, collapse), which society cannot simply accept. By ensuring a continuous regeneration process, the protective function of the forest can be guaranteed, regardless of possible hazards (from storms, etc.) (Kanton Wallis, [no date]a).

At the national level, the situation is similar, although the focus extends beyond protection to include the forest's broader social functions—not only its protective role but also its provision of resources such as timber and its recreational value. In a report responding to parliamentary questions on forest adaptation to climate change, the Swiss government defines one of the main objectives for the "desired ideal state in 2050" as follows:

> The Swiss forest will be preserved as a diverse, resilient and therefore adaptable ecosystem with all the services it provides. As a near-natural habitat, the forest will continue to fulfil its functions for society and the economy even under changing climate conditions (adaptation) (Bundesrat, 2022:10).

Given the central importance of protective forests, it is not surprising that these statements are formulated with a tone of clarity—even necessity ("indispensable," "cannot accept," "will be"). The issue is not merely whether a certain timber yield can be achieved, as in traditional commercial forestry, but rather the preservation of infrastructure that is economically valuable, tied to local heritage and livelihoods, and—during natural hazards—crucial to human life. The task, therefore, is to preserve the biophysical status quo so that it continues to serve its desired social function.

The logic underlying this link between nature and society is particularly revealing: nature is framed both as the source of socially undesirable phenomena ("natural hazards," "collapse") and as a provider of "services" to society, which can be secured through safeguarding natural adaptability and regeneration. Nature thus offers a range of possibilities from which humans seek to select desirable outcomes through targeted practical measures. Although the scope of what is possible in nature exceeds human reach, humans nevertheless remain positioned at the centre—as drivers or regulators of what becomes actualised.

The interviews at times echoed this reasoning:

> The protective forest must be able to perform its protective functions permanently. That is the decisive factor for us. Everything else is secondary. […] First and foremost, the intervention is carried out in such a way that the protective effect remains at least the same or, ideally, is even improved (Interview "Government employee 3(1) (cantonal)", September 2022").

> You don't want to miss out on losing this protective effect. That's something you definitely don't want. […] Let's say, purely from a landscape perspective, it might be okay for this forest community to change. I don't think that's such a big deal. But we really need this protective function (Interview "Forester 11", October 2024).

These quotations show how forestry practice—identified in Section 7.1 as a practice *with* nature—is nevertheless determined by the goal of preserving the protective effect; no other form of practice appears conceivable. Yet, as Forester 11 notes, this goal may not align with what would occur naturally—that is, without human influence. Accordingly, maintaining the protective function is not always a practice *with* nature but may become one *against* it: the forest as a community of species would adapt in one way or another to climatic change, but this adaptation might not correspond to the socially desired outcome of protection.

Thus, the societal goal of preserving protective forests becomes a causal force shaping practice. Like all causal forces, however, it should not be understood as deterministic but as a potential that interacts with other forces and may therefore remain unrealised. Nevertheless, in the quotations discussed so far, preservation appears not merely as a possibility but as a necessity. At the same time, it cannot be regarded as self-evident—if it were, there would be no need to assert it explicitly, institutionalise it as political strategy, and pursue it through practice.

What structures such references—and indeed the entire field of FACC in Valais—is precisely this contradiction: on the one hand, the normative goal of preserving protective forests appears undisputed, even self-evident; on the other, this goal is not inscribed in the nature of things—otherwise it would not require continual reaffirmation. Here, the transcendence of natural possibilities over anthropogenic aims becomes visible: events in the biophysical world may elude human normative intentions.

This contradiction is clearly illustrated in a quotation from the report on forest adaptation in Valais, which I have already cited several times:

> "The forest doesn't need foresters" is something you hear more and more often. Certainly, over time, decades or centuries, the forest will adapt to climate change and extreme weather conditions (climate accidents). But in Valais, 87% of its area fulfils a protective function. The sudden loss of forest cover, whether due to storms, fire or pest infestation, will reduce or completely negate this protective effect (Métral 2015:11).

Here, forestry practice is legitimised through the contradiction that nature inevitably changes, yet such change does not necessarily align with human or societal desires. The logic that "a forest does not need a forester, but a forester needs a forest" situates society within nature's constellation while still presuming that nature can be shaped into a desired form through human practice—thereby subtly subordinating nature to human control.

However, within this human–nature dualism, alternative interpretations also emerge that question the very premise of maintaining the protective function. Sometimes these appear only as abstract allusions, as in the following statement by a forester:

> Nature is always capable of surviving somewhere. It has always been that way. But humans may no longer have a place there. That's the other thing (Interview "Forester 7(2)", October 2024).

This more philosophical reflection resembles the earlier quotation from Métral's report: it begins by asserting that climate change is not a problem for nature. Yet rather than deducing the necessity of human control, it directly addresses the possibility that the desired goal may not be achieved. The field of the possible is thus reopened: instead of being closed by the apparent necessity of preservation, it expands through the recognition that humans *may* lose their central place in the world. Humans become, in a sense, subordinate to natural forces and must accept when these forces fail to manifest in the desired form of a protective forest.

Sometimes the possibility that the forest's protective function can no longer be maintained is addressed more openly, albeit with rhetorical caution:

> This year, for the first time in Switzerland, there were voices saying, "Maybe security can no longer be guaranteed in certain regions." This means that the inhabitants can no longer stay there. In the past, this was a taboo in Switzerland. […] You could protect everything with technical or natural measures. Everything was possible. Suddenly they say, "Aha, maybe not after all." (Interview "Government employee 4 (national)", December 2024).

The interviewee referred to several severe rainfall events during the summer of 2024 that triggered mudslides in Valais and other Alpine regions, burying roads and residential areas and causing multiple fatalities. Although these events may not have been directly linked to a failure of forest protection, the interviewee raises a broader question: to what extent can the forest's protective capacity still be guaranteed under altered climatic conditions?

Even though the statement is phrased in the third person—likely reflecting the diplomatic tone typical of federal officials—the very act of acknowledging this contradiction reveals a position: for this individual, it is legitimate to question whether infrastructure protection can still be assured. Particularly noteworthy is the claim that "everything was possible." Here, "possible" refers not to a transcendental horizon but to what was once considered practically achievable from an anthropogenic perspective. Protection had been assumed attainable through natural or technical means; its failure was effectively unthinkable. Now, however, events once deemed impossible have occurred, demonstrating that not everything can, in fact, be protected.

Another forester made a similarly clear statement regarding what should be done in view of a potential loss of protective function:

> It must also be stated quite clearly: The hazard maps must… We simply have to give nature and the whole dynamic more space. We have to take a step back here. Definitely. […] We must also have the courage to correct certain mistakes that have been made. […] Built too close to the stream beds. Expanded too far. Give nature back its space. […] And in future, we simply have to have the courage to backtrack. You can't just say that the forest has to deliver the services [*laughs*] (Interview "Forester 11", October 2024).

Notably, this is the same forester who earlier insisted that "we really need this protective function." Here, the imperative appears less absolute—or rather, it is displaced by another necessity: the need to grant nature more space by dismantling certain anthropogenic structures. This again reflects the transcendence of natural forces over human intentions. Humans cannot freely select among nature's possibilities but must instead respond to what nature affords, thereby challenging a command-and-control logic.

Much like natural regeneration, the imperative to preserve protective forests functions as a structuring element within the discourse on forest adaptation: it narrows the field of possibilities by defining a specific and seemingly unequivocal purpose. Preservation rests simultaneously on possibility (it can be achieved) and normative necessity (it must be achieved), with the latter typically taking precedence. Yet, as shown above, some voices question—or even invert—this hierarchy: anthropogenic ideals, and humans themselves, appear to be losing their central position, while the possibility of at least partial loss enters the horizon of thought.

However, unlike the wildlife debate, no open conflict has yet emerged between these positions—only subtle indications of an incipient questioning of the dominant protective-forest discourse. This discourse itself acts as a causal force that structures, and thus partially closes, the field of possibilities. Yet by juxtaposing this necessity with ongoing natural change and its inherent contingency, the field is simultaneously reopened when actors reflect upon and challenge the very norm that structures it.

In sum, Section 8.1 shows that clearly opposed positions regarding the preservation of different forms of nature—such as in the cases of wildlife and Robinia—politicise FACC. By contrast, such oppositions are less pronounced in debates on natural regeneration and protective forests, where they are only beginning to surface. Paradoxically, from a forester's perspective, these latter cases generate greater uncertainty and openness than those marked by explicit political conflict. Dominant discourses on natural regeneration and protective forest conservation close the field of possibilities by presenting these elements as necessities. Yet new possibilities arise precisely through the questioning of these necessities, invoking both the transcendence and contingency of natural change. Within this continually closing and reopening field, actors must position themselves and navigate their way forward.

8.2 The struggle for legitimacy: Defining forestry's place in society

In this section, the analysis shifts from examining differing positions and negotiations over how forests should be adapted to climate change to exploring how forestry seeks to define—and

ultimately legitimise—its own role within society and in relation to other social actors. I first examine how foresters refer to the public and its perception of the forest, and how these references become causal factors shaping the forest of the future in a search for legitimacy (Section 8.2.1). I then reverse the perspective to ask why forestry seeks or requires such social legitimacy in the first place: first by examining the acquisition of financial resources (Section 8.2.2), then by turning to the media, understood as a causal actor that both informs society about forest-related problems and contributes to their legitimisation (Section 8.2.3). Finally, I trace how a sense of responsibility towards society emerges in forestry (Section 8.2.4).

8.2.1 Mobilising the public, legitimising forestry

In one interview passage that initially concerned the "problem" of game and the absence of its reduction through hunting, the interviewed forester suddenly shifted from discussing hunting practices to reflecting more generally on the relationship between the public and forestry:

> The shooting planning must be greatly increased. Otherwise, we will have even more [animals]. And this understanding is simply lacking everywhere. Nobody cares about the forest! I say that deliberately because that's how it is. The public, the people, don't care about the forest. They don't give a damn! (Interview "Forester 4", February 2023).

The forester explains the absence of higher hunting quotas—and thus the continued presence of game—not only by the fact that hunters shoot too little, but rather by what he identifies as a general lack of public understanding of forestry ("the forest") and its concerns. The causal logic underlying this view is that, if the public cared more about forests, there would be stronger pressure to increase culling quotas, thereby improving natural regeneration and helping forests adapt to climate change. In this sense, "the public" (*die Öffentlichkeit*) is conceived as an actor endowed with causal power that contributes to the possible forest of the future.

At the same time, the concept of the "public" remains vague: it is not entirely clear who is meant by this term or how exactly the public can contribute to forest-related outcomes. Nevertheless, it recurs frequently in my interviews and in policy documents and thus emerges as a key factor in discussions about forest adaptation to climate change. It is sometimes also referred to as the "population" (*Bevölkerung*) or "people" (*Volk*). The Federal Office for the Environment (FOEN) has even conducted three population surveys over the past 30 years under the title *Forest Monitoring Sociocultural* (*Waldmonitoring soziokulturell*, WaMos), with the aim of understanding "how the Swiss population perceives and uses the forest" (Dirac and Schmutz, 2022:11; see also Hegetschweiler et al., 2022).

The results of these surveys repeatedly show that the Swiss population has a strong interest in forests, particularly regarding their recreational value. At the same time, climate change is increasingly perceived as a threat: in the most recent survey (2020 data, published in 2022), over

30% of the more than 3,000 respondents identified climate change as the greatest threat to forests as a habitat (Hegetschweiler et al., 2022:50).

These findings seem to contradict the forester's claim that the population is not concerned about forests. Nor was he the only interviewee who lamented the lack of public attention to forest-related problems. Several sought to explain this indifference:

> The public doesn't really believe in it [the effects of climate change in forests] yet. We've always tried, even with hunters and so on, to raise the issue and tell them that in 50 years' time we'll simply have a deciduous forest [...]. We're trying. But it's hard to believe because you can't see it (Interview "Forester 11", October 2024).

> It [the effects of climate change] is visible to foresters [...but] it's not visible to the general public. There is a minority who is observing it. But on the whole, the forests are green. We're not facing forest dieback. [But] trees are dying. More than ever before (Interview "Government employee 4 (federal)", December 2024).

> Young people have no idea what's going on, what nature and all that stuff is all about. They have no connection to it anymore. Children grow up in little houses somewhere and then maybe they go shopping with their mum. And then they're back at the playground, if they're lucky. That's about all they see (Interview "Forester 7(2)", October 2024).

These quotations not only express disappointment at the public's limited attention to forests and climate change but also offer explanations for it. All three follow a similar logic: the problems caused by climate change are not visible to the public. Hence, a distinction is implicitly drawn between the empirical and the real levels in the sense of critical realism, where it is assumed that not everyone interprets the same empirical phenomena in the same way, and that knowledge itself depends on social context—in this case, education and profession. Foresters, in this view, interpret the effects of climate change on forests differently from the general public, whose perspective is shaped by processes of socialisation. Even though the effects are not immediately visible to the public—such as in large-scale "forest dieback"—deeper, hidden causal elements of climate change are at work, and only forestry professionals experience them directly.

However, the WaMos survey results appear to contradict these explanations: over 40% of respondents said they had observed signs of climate change in forests (e.g. dead trees) (Hegetschweiler et al., 2022:20). FOEN summarised the situation as follows:

> Many people are noticing the effects of climate change: they see dead trees and trees that are suffering from drought. Forests that are changing in appearance are becoming more common and are noticeable to the population. Climate change is therefore cited as the greatest threat to forests (Dirac and Schmutz, 2022:7).

Such results from a survey with several thousand respondents obviously cannot be directly compared to individual statements by forestry professionals such as those cited above. Individual foresters make such statements from within a field of social actors in which they are compelled to act and justify their actions, whereas the survey generalises from responses to standardised

questions. This is not to suggest that the survey results are "truer" in the sense of being less biased, as such standardised questions can themselves induce observer bias (Sayer, 1992:245–246).[61]

In this regard, a closer look at the survey methodology may be illuminating. For instance, respondents were asked: "What do you think is the greatest threat to the forest?" (single answer, with ten possible options such as climate change, waste, urban sprawl, and nitrogen inputs; Hegetschweiler et al., 2022:160). Another question read: "Have you noticed any changes in the forest you regularly visit that may have been caused by climate change (e.g. broken branches, dried-up crowns, dead trees, new species)?" (Yes/No; Hegetschweiler et al., 2022:157).

Such questions reduce climate change to a single, identifiable, and discrete variable among many, even though—as demonstrated throughout this study—climate change cannot be understood as an immediately perceptible or uniform phenomenon. It is complex, heterogeneous, and often ambiguous, even for experts such as foresters or scientists. Consequently, the survey faces limitations similar to those of the perception studies discussed in Section 2.3: it infers general conclusions from correlations between simplified variables, suggesting, for instance, that "the Swiss population values forests and is concerned about them in view of climate change" (Dirac and Schmutz, 2022:7). These statements operate primarily at the level of observed perceptions. By contrast, the foresters' statements concern the causal role—or its absence—of the public as a force capable of influencing forest practices and thus shaping the forest's future. This difference helps explain the apparent contradiction between the interviews and the survey results.

Furthermore, as shown in Chapters 6 and 7, the main challenge for forestry is not "climate change" as such (if it can even be treated as a single, coherent phenomenon), but rather the uncertainty surrounding it and the practical decisions this uncertainty entails. Yet questions of uncertainty were absent from the WaMos survey. Hence, the survey's methodological approach is ultimately at odds with the actual problems forestry faces; the two address fundamentally different objects of inquiry.

In the end, it may be less important to ask why the public appears inattentive (or not) and more revealing to consider why actors in the FACC field invoke "the public" at all—why it becomes a causal force for the future forest. The possibilities opened by this causal force are illustrated in the following quotation:

> We in the forestry sector must take the initiative and go to the public and say, "Look, things cannot go on like this." And if the public then takes note of this, [...] then the likelihood that politicians will take up the issue is also greater. The population must also—

[61] When I asked an FOEN employee (whom I encountered at a conference) about this apparent contradiction between my findings and those of WaMos, he responded in a similar vein. According to him, sampling bias may partly explain the discrepancy, as the survey likely reached individuals already interested in forests more readily than others (field notes, 1 October 2025).

> how shall I put it?—recognise this as a problem. And if the population sees this, then politicians must also respond to it. Perhaps questions will then arise from the public or from the Grand Council [the cantonal parliament]. If you look at the politicians who are from the region, you can encourage them to submit motions to Sion [the canton's capital] and then table them in the Grand Council. And then the State Council [the cantonal government] will have to respond. In that sense, the government department will also have to come back and provide an answer (Interview "Forester 7(2)", October 2024).

In this passage, the forester again discusses the topic of wildlife management and the political reluctance to reduce game populations. However, this reasoning applies analogously to the entire FACC context. The repeated if–then structure of his statements reveals the socio-political embedding of FACC: the forester, as an acting subject, situates himself among other actors and seeks to exert causal influence through these relationships. He describes efforts to bring together the cantonal administration and forest owners to develop strategies for wildlife management, as well as initiatives to take school classes into the forest to teach them about climate change. Similarly, other foresters (e.g. Foresters 1, 2, and 4) reported leading public excursions or lectures on forests and climate change to "raise awareness" among "the population."

On the one hand, the public is seen as a force that transcends both individual foresters and the forestry sector more broadly, operating according to its own logic—sometimes diverging from that of forestry. On the other hand, this causal force is not fixed: foresters actively attempt to influence public opinion to make it more attentive to forest concerns. In this sense, the public becomes a field of practical possibilities—an arena in which foresters pursue legitimacy for their work through social relationships.

8.2.2 Funding adaptation: The possibilities of financial resources

Ultimately, one might ask why the forestry sector struggles for greater legitimacy for its work. The most obvious answer—examined in this section—concerns resources, specifically financial ones. In this regard, the following remark by a government employee is revealing: "Of course, foresters always say, 'There's not enough money'" (Interview "Government employee 3(2) (cantonal)", February 2025). Indeed, financial resources emerged repeatedly as a topic in interviews with foresters:

> I have the feeling that forestry policy needs to broaden its horizons a little. That means clearly putting it on the political agenda that more money is needed, because otherwise we'll hit a brick wall at some point. There is always a tendency to react rather than act. In other words, we should look at what the financial requirements are so that we can really prepare the forests for what is coming, rather than looking at how much money we have and then seeing what we can best do with it. Whether you get the money is another question, but at least they should define it and say, "The Swiss forest needs XY times 100 million per year over the next 30 years to make the forests a little more climate-fit" (Interview "Forester 10", October 2023).
>
> We are actually always arguing a bit with the canton about the amount of money we receive. Because you stretch yourself to the limit. When I do protective forest

> maintenance, I use up all the money until I have nothing left. To put it bluntly. That means if I can sell the wood for more, I can do a little more. If I can't sell the wood for as much, I have the same amount available. That means at some point you have to say how much I can… We have a special-purpose association [*Zweckverband*], which means the municipalities bear the remaining costs. […] And then, ultimately, you have to decide in the forest how much we can do with the money we have available. You can't just go and hoo-hoo [sic] and at the end of the year say: "Now we've made 200,000 Swiss francs less, now you [the municipalities] have to pay." That doesn't go down well. Because they want to budget for it too (Interview "Forester 7(1)", February 2023).

These statements clearly show how financial resources structure the relationship between forestry practitioners and political administration. From the practitioners' perspective, two distinct logics emerge: either one takes the available funds and does what is possible to maintain the protective forest, or one defines the preservation of protective forests as the goal and allocates the corresponding financial resources. In both logics, a fixed necessity and dependent variables delineate the field of practical possibility.

At the same time, the politically mandated organisation of forest management in Valais favours the first logic—"do what you can with the money available." Typically, several municipalities form a forest district, each with a head forester who fulfils a dual role: as a public administrator responsible for forestry policing, and as the director of an operating company that carries out practical work for the forest owners. Over 80% of forests in Valais are owned by so-called Burgerschaften or Burgergemeinden (Grand, 2015). These historically rooted institutions perform public functions alongside formal political authorities (municipality, canton, and federation), including forest management and cultural heritage preservation. While membership was once restricted to privileged village residents, this has since changed—although many political careers in Valais still begin within the boards of Burgerschaften.

District foresters must therefore manage their operations to avoid financial losses for these forest-owning entities (which, as seen in the second quote above, "doesn't go down well"). They must plan their activities to ensure economic viability—if not profitability—so that forestry operations remain sustainable in the future. This apparent necessity implicitly presumes a secure and predictable future.

However, the seemingly obvious source of forestry income—the sale of timber—is not profitable. In mountain forests, particularly those designated as protective forests, timber harvesting entails significant effort. Traditional logging methods often require cable cranes or even helicopters. Moreover, ensuring worker safety on steep terrain demands additional material and labour costs that cannot be recouped through timber sales alone. Between 2012 and 2023, timber revenues covered only about a quarter of the gross costs of protective forest management in Valais (Werlen, 2024:3). In short, as one interviewee put it: "The price of wood does not pay for the work" (Interview "Forester 5", February 2023).

Because forest management is not financially self-sustaining—yet remains a matter of public interest—it is supported by public funds. These are approved by the cantonal legislature and implemented by the executive. The canton provides CHF 9,000 per managed hectare per year, supporting just under 2,000 hectares annually between 2019 and 2023 (Werlen, 2024:2; Interview "Government employee 3(2) [cantonal]", February 2025). Ultimately, these funds originate from the federal government through national financial equalisation (*Finanzausgleich*). Between 2008 and 2021, the federal government subsidised the Swiss forestry sector with an average of CHF 150 million per year—almost half directed to protective forest management and nearly a quarter to protective structures and hazard identification (Bundesamt für Umwelt and Eidg. Forschungsanstalt für Wald, Schnee und Landschaft, 2025:114). These subsidies have recently risen by CHF 25 million following several political motions addressing climate change (ibid.: 115).

Funds are allocated when foresters document their interventions according to the NaiS implementation guide (Frehner et al., 2005; see also Section 8.1.4). The guide's aim was to provide a "practical tool" ensuring "a sustainably effective protective forest with as little effort as possible" (Frehner et al., 2005:12). It thus serves as a means to plan, document, and verify interventions so that the funds can be disbursed.

Without delving into the complexities of Swiss fiscal federalism, the key point is this: the majority of forest management funding—especially in cantons like Valais, with a high proportion of protective forests—derives from public sources, whose efficient use is governed by NaiS. Yet this efficiency logic itself produces problems, as a cantonal employee explains:

> We pay around 9,000 Swiss francs per hectare, and then theoretically we can come back sometime after 20 or 30 years. And when you manage a forest or part of a forest, you cut never all wood down, but rather in sections. But these areas must be able to regenerate so that we can move on to the next area and maintain the layering. And […] if the young trees don't grow […], you're left with a grassy island that offers no protection against natural hazards. […] And that's partly the case with us. Of course, you can't say that too loudly. It's a huge political problem. […] Because that's the philosophy behind NaiS, sustainability in protective forests: with as little intervention as possible, with a big leverage effect… But if you do something that has no leverage effect at all… Well, then it's a problem. Then you're wasting public money. [*and later in the interview*] Of course, foresters always say, "There's not enough money." That's clear. There's never enough money. But if you gave them 20,000 Swiss francs [instead of 9,000 CHF/hectare], it would still be too little. And they would indeed need the 20,000. It's not like they don't need it. But then you're with the NaiS philosophy… [In the past], this was actually called minimal protective forest maintenance. So you really try to achieve the greatest possible leverage with the least possible effort. And with this philosophy, we are already paying enough in that sense. But you could always do more (Interview "Government employee 3(2) (cantonal)", February 2025).

This situates the previously heard claim that "there is never enough money" within a broader context. The employee describes the politically imposed necessity of demonstrating effectiveness: public funds must be spent on measures whose effects are visible and verifiable (see in this regard

also Section 8.3.4). The difficulty is that such effects only become apparent after 20–30 years—and even then, only if the intended outcomes materialise. The "if" here is crucial: if young trees fail to grow despite interventions, for example due to browsing or future climatic extremes, the logic of efficiency collapses. NaiS thus reflects a Humean understanding of causality—where causes and effects are confined to observable events—overlooking the potential influence of hidden or emergent causal powers.

A federal employee articulated a similar tension in discussing the possibility of tree planting:

> Planting is an investment. You take money, often public money. You need public money. That means you have to be reasonably sure that you are investing it wisely. And we are in a state of uncertainty [*laughs*]. [...] But when you invest money, you take a risk. And when you try natural regeneration, you need less money, at least in the beginning. Sometimes you need more time, but often it's not a problem to take a little more time (Interview "Government employee 4 (federal)", December 2024).

Here, the political preference for natural regeneration over planting is justified not only by cost. Even if planting were more expensive, it would enable more targeted adaptation to climate change—if the desired future forest were known. Yet, as repeatedly emphasised, this is not the case. Consequently, planting cannot be politically justified, and natural regeneration becomes the default strategy.

Beyond public funding and timber sales, forestry operations have sought alternative financial channels—thus expanding their field of practical possibilities. One such avenue is CO_2 compensation (or "sink") projects, in which forest use is restricted (i.e. logging suspended) so that standing biomass can sequester carbon. Polluting industries, such as those in oil or aviation, pay foresters through intermediaries like MyClimate to offset their emissions—a practice described in several interviews (they often referred to the method by Schmidtke, 2018).

However, this approach is controversial among foresters:

> There are various ways of trying to assess the value of the forest's services. There are sink projects. [...] [But] from my point of view, it's a bit of a credibility issue when you say, "We need to do more in the forest, we need to thin out the trees so that deciduous trees can establish themselves," and at the same time you want to implement CO_2 compensation projects where you refrain from using the forest [i.e. cutting trees]. Then I have to say [...]: "Wait a minute, on the one hand you're collecting money for not doing something, and on the other hand you're saying, 'we have to do more'. That's a bit of a contradiction" (Interview "Forester 10", October 2023).
>
> I'm not really in favour of [sink projects] per se. Because that's not the primary solution. Because it doesn't do anything for climate protection. It's actually—although no one likes to hear it—just greenwashing. And nothing else. [...] You're making a commitment that you'll probably have problems keeping. Because it's about giving up a certain amount of wood use and then you're not allowed to fall below a minimum amount of wood stock in the area, which has to be declared. And if you do, you have to pay the money back. [...] If the stocks then decline due to the mortality we're currently experiencing... They will decline, that's logical. And mortality on this scale means an extreme

> decline in the timber stock, in the living timber stock. Because dead wood is not considered a CO_2 repository. Because it is released back into the atmosphere. […] And to a certain extent, it's a fallacy to make a 30-year commitment that you may regret in 10-15 years. And if it breaks down, if it doesn't really work with the repayments, then it's all lies and deceit anyway (Interview "Forester 7(2)", October 2024).

Through the lens of these foresters, these CO_2 sink projects embody a rigid cause–effect logic: money is paid on the condition that trees remain standing for a fixed period to ensure carbon storage. Yet here, too, an "if" appears: if the trees die prematurely due to extreme weather, decay releases the stored CO_2—creating a triple failure: carbon is not sequestered, the forest loses its protective function, and the funds may need to be repaid.

These foresters therefore reject such compensation schemes. On one hand, their field of practical possibilities is constrained—they cannot harvest timber. On the other, as Forester 7 emphasised, even non-intervention does not guarantee the desired outcomes.

In response, a group of forest owners and forestry companies in Valais founded an association in 2023 to raise funds through crowdfunding. The initiative aims to "make the forest more resilient and fit for climate change" through measures "beyond those currently undertaken by the public sector" (KlimaWald Wallis, 2025). Unlike compensation schemes, this approach seeks to expand the field of practical possibilities by attracting additional resources. The targeted measures involve thinning, planting, direct sowing, and protecting young trees from browsing (see Section 7.3). Specific projects are advertised online, and funds are raised through individual or corporate donations.

This reflects the second logic noted earlier: defining necessary adaptation projects first, then seeking the resources to implement them. These projects invoke a discourse of security—erecting fences "to ensure the survival of these young trees" or planting "to preserve the protective function of our forests" (KlimaWald Wallis, 2025). Although the website acknowledges the uncertainty of climate change, this uncertainty is attributed primarily to "social, technological, economic and political variables" in global emission scenarios and models. Thus, even here, the language of security serves as the primary fundraising tool.

Examining the complexity of financial procurement and flow reveals two things. First, the pursuit of financial resources is indeed central to the power dynamics shaping FACC in Valais. Money enables practical interventions and opens a field of practical possibilities. Second, these financial logics are deeply entangled with assumptions about the openness—or closure—of the future. NaiS and CO_2 sink schemes presuppose that causal effects must be empirically observable and predictable, while crowdfunding invokes security as something that can be purchased in advance. In all cases, the notion that "everything is possible as long as funding is available" proves limited.

8.2.3 The media's forest: Constructing concern, obscuring uncertainty

With the allocation of and search for financial resources linked to a certainty and predictability of the effects of interventions, the actual problem of uncertainty described in Chapters 6 and 7 is not directly addressed. In this section, I therefore explore further the forestry sector's search for legitimacy for its concerns and work, in this case through the media.

As an entry point to this topic, the following observation during an interview with an employee of FOEN is illuminating. In the midst of the interview, the interviewee suddenly turned away from me, opened an email on his computer, and said:

> Here I have today's media reports [*shows a list of the media reports on his computer screen*]. And every day, about a quarter of the articles are about wolves. [*quotes titles of media reports*] If the political will is there, action can be taken very quickly! (Interview "Government employee 4 (federal)", December 2024).

The interviewee compares the wolf debate with forest adaptation to climate change, the latter being his own field of expertise. As shown in Section 8.1.1, the wolf issue is only indirectly related to forest adaptation to climate change. However, it is highly politicised and emotionalised in Switzerland, particularly in Valais. The interviewee thus seeks to illustrate how little media coverage the issue of forest adaptation receives in comparison. He also assumes that greater media attention would trigger political measures, since media discourse exerts a causal influence on "political will."

Foresters, too, referred in interviews to the lack of media attention given to FACC, and they offered various explanations for it:

> You get that feeling when you read the newspapers too. When you see the headlines in Blick [a Swiss boulevard newspaper] or wherever, then boom! They sell well, but what we do here every day isn't interesting. It's actually the complete opposite of what they publish. At completely the wrong time (Interview "Forester 5, February 2023").

> They [the media] are always interested when you can pick them up. But it's the same thing again: it has to be interesting for the media. If you can deliver that, then that's good. And then it's actually important that you can deliver it again and again. Because [...] you read something because there's so much out there, and then you might read something superficially. [...] A day later, it's already gone. [... *a little later in the interview, the forester comes back to this*:] If other interests prevail because they are more interesting, then we're simply out of luck. [...] You can see that clearly in what's going on in America, it's kindergarten! It's a bloody theatre! I mean, it couldn't get much worse. And that's just... And then there are a bunch of issues in the world that need to be addressed, and one of them is climate change. If that's not seen as a major issue or a big issue, then it'll just go down the drain again. [...] Then some war will come along and climate change will be back in the corner again (Interview "Forester 7(2)", October 2024).

These two quotes lament that the FACC issue fails to generate sufficient headlines and is therefore deemed "uninteresting" by the media. Once again, timing plays a key role: long, gradual processes ("day after day," "again and again") appear less newsworthy than sudden, dramatic events

("boom!"). Forester 7 even compares FACC to the American election campaign of autumn 2024, whose "theatre," as he puts it, manages to produce an endless sequence of such fleeting, short-lived moments. Although he actively tries "to pick up the media," it seems journalists find little appeal in repeatedly reporting on the same phenomenon.[62]

In this line of argument, the FACC issue remains insufficiently visible to the public because the media does not cover it enough. As mentioned in Section 5.2.1, I systematically collected publications from the Valais daily newspaper *Walliser Bote* and from the Swiss national broadcaster SRF (including articles on its website) from the beginning of 2020 to the end of 2024, as well as many other media reports.

I was initially surprised by how many articles on forests and climate change appeared, thereby seemingly contradicting the foresters' statements. However, a closer reading of the media coverage reveals a more nuanced picture.[63]

What struck me most was how closely many reports were linked to specific events: the publication of scientific studies, parliamentary debates, or the visible effects of the dry summer of 2022. The topic of uncertainty, however, was almost entirely absent: in the more than sixty articles analysed, the terms *uncertainty* or *uncertain* appeared in only one. Especially in headlines—often the most widely read part—articles tended to assert apparent certainties: "Climate change puts Swiss stone pines in distress" (pomona.media-Redaktion, 2021); "Beech dieback in Swiss forests" ([no author], 2023). Such articles typically summarise recently published scientific findings.

Other headlines emphasised transformation, though in rather abstract terms (as discussed in Section 6.1.1): "'The forest will look different in the future'" (Hofer, 2022). Frequently, headlines took the form of questions: "What trees does the forest of the future need?" (Vitelli, 2024); "The future of Swiss forests—which trees will survive rising temperatures?" (Rothenbacher, 2023); "What happens when nature and forests change?" (Dussault, 2023). Yet these questions should not be read as expressions of uncertainty; the body texts generally present answers of scientific "experts" that resolve rather than open up ambiguity.

In the body of the texts, there are occasional hints at possibility and openness to the future, often expressed through conditional clauses—for instance: "If climate change continues to make the climate warmer and drier, the Swiss stone pine is at risk of being displaced by faster-growing spruce, fir and deciduous trees" (pomona.media-Redaktion, 2021). Yet even here, the sense of possibility diminishes under the shared assumption that climate change will continue.

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[62] I myself contacted two journalists—one working locally in Valais and another at the national level—to ask whether they might be interested in writing something on the topic of uncertainty in forest management under climate change, based on my research on this topic. However, I never received a reply.

[63] It should be noted that this does not constitute a representative or statistically rigorous media analysis; rather, I examined the texts through the interpretive lens developed over the course of the research.

Some reports illustrate forestry's challenges vividly. One article from the *Walliser Bote* presents a district forester's perspective:

> The forest is suffering throughout the Upper Valais. This is particularly serious in a mountain canton: according to the canton of Valais, 87 per cent of Valais forests are protective forests.
> Without them, many mountain villages and valleys would no longer be adequately protected from natural hazards. […]
> It is becoming increasingly clear that the rise in temperature is too rapid for the slow-reacting forest. In the area from Bitsch to Fieschertal, 80 per cent of the forests consist of spruce trees. However, spruce trees can no longer survive at the current altitudes. These are shifting upwards by one hundred metres per degree. As a result, spruce trees will retreat to higher altitudes in future due to the higher temperatures.
> This means that new tree species will have to be introduced in areas where spruce trees currently dominate. Possible tree species that could replace spruce include birch, rowan, service tree and sessile oak. A change from coniferous to deciduous forests is therefore necessary. But how can this be achieved? (Rovina, 2023).

Here, a series of seemingly specific causal factors in nature are mobilised to describe forestry's predicament. A change in tree species is described as normatively necessary, yet this necessity is countered by the slow pace of natural change. The rest of the article follows the forester in his efforts to promote natural regeneration, hindered by extensive browsing by wild animals.

On the one hand, such portrayals clearly illustrate forestry's practical problems and possible responses. On the other, they reproduce a socially prescribed necessity—the preservation of protective forests—which is taken for granted and thus removed from the realm of possibility (see Section 8.1.4).

This brief overview shows that although the media do cover the effects of climate change on forests, they rarely connect these effects to the uncertainties and multiplicity of possible futures that define forestry practice. The issue, then, is not whether the media report on FACC, but how they do so. The following statement from a forester, referring to the forest dieback debate of the 1980s, points to this problem:

> There was once the issue of forest dieback [*Waldsterben*]. It was completely exploited by the media. People blamed each other for saying the wrong thing in the wrong place. That's why people are relatively cautious with such expressions today (Interview "Forester 5", February 2023).

This forester recalls how the media excessively exploited the forest dieback debate at the time, suggesting that he would not wish the same for today's FACC issue. From this perspective, the goal is not to subject FACC to an attention economy reminiscent of an American election campaign. Rather, these remarks reflect the view that the way media represent the issue does not correspond—and perhaps cannot correspond—to the everyday realities of forestry practice.

In this sense, the issue may not be a lack of awareness of climate change and its effects on forests, but rather how these topics are framed within the media. The elements highlighted in the

previous chapters—the uncertainty about what the future holds and the muddling-through as a practical strategy for coping with it—seem largely absent from media discourse. What emerges through this discourse is therefore not an open or multiple set of possible futures (as discussed in Chapter 7), but a seemingly closed or determined path toward the future. Because media and public discourse negate uncertainty and indeterminacy, these very absences heighten uncertainty from the perspective of forestry actors—prompting them to seek legitimacy all the more urgently.

Thus, on the one hand, forestry actors use the media to exert greater pressure on political authorities, in which financial resources may play a crucial role. On the other hand, the results of this section point to something beyond funding. What is at stake is the absence of uncertainty in media representations—an uncertainty that foresters confront in their everyday work and that cannot simply be resolved through increased funding. I will explore the social significance of this uncertainty in the next section.

8.2.4 Responsibility without answers: The weight of the uncertain future

As already mentioned, all of the stakeholders I interviewed (with one exception) saw climate change as a key issue for forestry. At the same time, the interviewees also referred to people who see things quite differently from themselves—such as Forester 1, who is actively restructuring his forest with climate change in mind:

> What we need now are one or two foresters who are willing to push a little harder. Perhaps we are considered dreamers in certain circles. I don't know. […] The [climate scenarios] are actually clear to me, I have no doubts about that. But I keep coming across groups where, at the end of the day, someone still says, "It [climate change] isn't a problem at all." At the [name of a workshop], it was really impressive: we spent two days discussing the topic [of climate change], and at the final meeting, someone raised a finger and said, "Why are you always looking to the future? You have to look back. It's always been there. […] It will sort itself out." [*laughs*] What are you trying to say here? [*laughs*] I think we need the new generation, and the new generation sees that. I've noticed that too, it's much easier to find arguments when you discuss it with them. I think that's really… We are… Our generation isn't there yet. Many are not yet ready to really see that change is needed (Interview "Forester 1", September 2022).

This example illustrates how the forester explains why the problem of climate change in forests is only slowly being recognised by wider circles: there are still many actors in society who do not yet acknowledge climate change or its extent. On the one hand, the forester is actively trying to promote the issue. On the other, he acknowledges the limits of his efforts and their largely unsuccessful outcomes, because ultimately "it will take the new generation" (he sees himself as part of the older generation). The necessary change simply takes time.

A federal employee expresses a similar view when discussing how forestry practices can be changed to focus more strongly on climate change:

> You have to be very patient. Sometimes it takes generations, although now is the time to talk about it, with climate change and the damage to forests. Tree damage too. If we don't ask the right questions now, we'll just pass the problems on to the next generation (Interview "Government employee 4 (federal)", December 2024).

Here, too, the passage of time appears as a necessary causal factor for change in forestry practice. At the same time, this causal relationship is immediately problematised by the fact that the problems are simply passed on to future generations. In this if-clause, a relationship is established between "we" (understood as the current forestry sector) and future generations. Within this relationship, "we" appear to possess the causal power to provide an answer in the present to the problems of future generations.

This "next generation" is not understood solely as the next generation of foresters. Given the central importance of the protective function in Valais (see Section 8.1.4), the problems affect a broader section of society. In this sense, the problems addressed are not solely related to forestry; if the protective effect of the forest is lost, damage to infrastructure and even danger to human life may result. It is therefore understandable that a forester states, "You also have a certain responsibility. That's fatal." (Interview "Forester 11", October 2024). This fatal sense of responsibility arises in relation to other social actors.

However, the attribution of responsibility does not only emerge in the diachronic relationship to future generations or the public as an abstract actor. In the following quote, a forester describes the practical response to the possibility of a bark beetle invasion as follows:

> The question is simply: do you start when it begins? Do you fight it selectively? Or do you say: in 10-20 years, everything will be gone anyway? What is the better strategy? They should perhaps define these strategies for once at cantonal or federal level. The moment we notice it at the front is always... That's how we feel... We are between the government and the population. We are the ones who then try to take responsibility as far as possible (Interview "Forester 5", February 2023).

The forester sees himself and the forestry community as positioned within a triangular relationship between the government and the population. He believes that government agencies are responsible, yet are failing to define the necessary strategies—thus shifting responsibility back to forestry practitioners. At the same time, such responsibility emerges from the questions posed at the beginning of the quote, that is, from the openness or practical possibility of what can and should be done.

A cantonal employee aptly describes how to deal with such an interplay between responsibility and uncertainty:

> You have to document carefully what you are currently considering. And then I believe that you are never to blame, you have never done anything wrong. And that is what we actually do with these NaiS forms. [...] And then, in 15 years' time, when you review it, you can say: "Yes, that didn't work well." In God's name, this happens. There can be various reasons. It may be that everything was done correctly from a technical point of

> view. But perhaps climate change is happening even faster. Eight dry summers—pfft, no regeneration could take place. It's all possible. But you documented it (Interview "Government employee 3(2) (cantonal)", February 2025).

The need to document practical measures described here can therefore be interpreted as a consequence of responsibility under uncertainty. Interestingly, the function of NaiS (see Section 8.2.2) is reinterpreted: it is no longer about using financial resources and implementing practical measures in an efficient way but about documenting and safeguarding one's own responsibility towards others. This reflects a different understanding of the future than that underpinning NaiS: not a closed future, but an open one, as underlined by statements such as "perhaps climate change is happening even faster," "eight dry summers," and "it's all possible."

Others, however, locate responsibility beyond the forestry sector itself:

> To a certain extent, humans must learn that they have to do something differently. Otherwise, it won't work out well. But at the moment, what needs to be done is absolutely nowhere near happening. So far, it's heartbreaking. Just look at what's going on right now. I mean, if the Russians are still shooting each other, that's obviously going to mean [more emissions]... And then, of course, there are all the natural events that also release pollutants. The thawing of the permafrost. We have no idea what lies ahead for us there. Methane is coming out of the ground in huge quantities. The forest fires that are everywhere, which are massively... Right, the CO_2 is gone again when that stuff burns. And that's on top of what we're releasing into the air from oil and other stuff. And that's just... Yes... You can't paint a bleak picture, but it's never a bad thing to think critically about it [*laughs*] (Interview "Forester 7(2)", October 2024).

Surprisingly, this is one of the few statements that refer to the problem and causes of anthropogenic climate change in its global context (only Forester 1 made a similar comment). With regard to the notion of responsibility, however, these references can be interpreted primarily as an attempt by the forester to show that it is not only he or the forestry sector that is responsible for doing something: the focus here is much less on the forestry "we" and much more on "they," that is, humanity in general. At the same time, the uncertainty—"We have no idea what lies ahead for us"—is explained by humanity's lack of awareness of its responsibility.

From a forestry perspective, responsibility towards society can thus be understood as a causal force shaping practical measures to adapt forests to climate change. At the same time, this sense of responsibility underlies the search for legitimacy and recognition within society. This responsibility—understood as the capacity to give an answer to the needs of others—becomes all the more significant precisely because no clear answer exists. In this regard, it may be this unfulfilled (and perhaps unfulfillable) responsibility that helps explain the search for legitimacy within the broader public.

In sum, in Section 8.2 I have interpreted the forestry sector's references to the public as expressions of a social relationship that, from the perspective of the forestry sector, can be understood

as a search for recognition and legitimacy. This search is less about gaining public acknowledgment of climate change or its impacts on forests as such, and more about what can practically be done in this context from a forestry point of view. However, for forestry practitioners, this is not (or at least not only) a matter of securing more public funds to implement increasingly "efficient" measures. After all, such efficiency cannot be guaranteed given the uncertainty and openness of the future. Rather, I have understood this search for recognition as being driven by a sense of responsibility towards society—one to which forestry may ultimately be unable to provide a definitive answer. In communication with the public through the media, it might therefore be more appropriate to demonstrate that efforts are being made to respond (in the form of practical measures), while acknowledging that this response is, and must remain, open-ended.

8.3 Governing the future: Temporal regimes in forest adaptation

In this section, I examine the broader social context that shapes both the struggles over nature discussed in Section 8.1 and the search for legitimacy explored in Section 8.2. Central to this analysis is the question of temporality and the future—an aspect that has appeared repeatedly throughout this study but has not yet been examined in its own right.

I begin by showing how temporal processes in nature are contrasted with those in society (Section 8.3.1). I then turn to two scientific approaches—and their reception in forestry practice—that attempt to define the future forest in the present: test plantings (Section 8.3.2) and climate models (Section 8.3.3). Finally, I address the pervasive and socially dominant concept of sustainability and examine how it is driven by an urge to render the future tangible (Section 8.3.4). Taken together, these sections demonstrate how a particular temporal regime governs forestry practice and social interpretations of problems, ultimately working to close the space of possibilities.

8.3.1 Short-term society, long-term forest

In the search for legitimacy and recognition examined in the previous section, one element used to explain the lack of social acceptance of the problem was the public's limited visibility of climate change impacts on forests. However, this becomes a "problem" only if it does not remain invisible indefinitely but eventually loses its latency and becomes—or can become—socially apparent. In the present case study, this would likely occur at the latest when the forest no longer fulfils its protective function in the event of a natural hazard. Or, as a forestry official explains:

> The forest works, and that's why we're struggling to get our message across. It starts when we have the delegates' meetings—these are actually the forestry experts from the respective *Burgergemeinden*—and have to tell them: "Be happy that the forest is showing a balanced budget." That in itself is not guaranteed, in that sense. And if the forest doesn't cost anything, then somehow it's not worth anything. And if you say to them

> now, “Look, we have a problem here. It doesn’t affect us, it will affect us in 20 years, then it will catch up with us.” That’s just… Foresters, we in the forest, work like that. […] But politicians simply work in four-year intervals. They’re not interested in anything else. It’s very, very difficult to tell them, [that] “in 20 or 30 years, we’re going to hit a wall. And then the forest won’t function anymore” (Interview “Government employee 3(2) (cantonal)”, February 2025).

The dialogical nature of this quote is particularly noteworthy: the actor explains how he and his colleagues from the cantonal forest section attempt to convey that things are not always as they seem. For example, the fact that forestry operations show a balanced budget does not mean that there are no underlying problems. In this sense, the apparent financial health of the present—represented by the “balanced budget”—does not reflect longer-term processes.

However, the core problem described here is not so much the current invisibility of these challenges, but rather the temporal shift and causal connection between two moments in time: on the one hand, the present, in which problems remain largely invisible (“the forest works”) while already developing at a deeper structural level; and on the other, the seemingly inevitable moment when they become manifest (“it will catch up with us,” “we’re going to hit a wall”). This analysis invokes two distinct temporal regimes: as part of biophysical nature, the forest is subject to processes that unfold over several decades, to which forestry has adapted its thinking. Political actors, by contrast, follow four-year electoral cycles or annual rhythms of budget planning, both oriented toward the manifest visibility of events. From this perspective, social processes operate on shorter temporal horizons than those of the forest ecosystem, even though the latter ultimately prevail.

The following statement by a forester, in which he discusses the game problem, supports this interpretation:

> And then the problem is that if you can’t anchor that [excessive game pressure] in politics, it creates a huge problem for us in the medium term. Then we can’t do anything [anymore]. If politicians don’t recognise that, you can forget it. The forest is slow-moving. Purely in terms of development. Nowadays, that’s actually the opposite of the development that usually happens. We are so short-lived and so extreme… How can I put it? Processes are always faster. If you order something today, you have to have it tomorrow. Preferably this evening. […] Just faster and faster. And when we in forestry, where we might be planning for a hundred years, come up with a problem that you as a specialist recognise, but the layman doesn’t see it and the politician doesn’t want to see it because he says: “Everything is fine, the forest is green” (Interview “Forester 7(2)”, October 2024).

It is interesting to observe how the forester moves from the specific problem of game pressure to a more general diagnosis. The factor linking these two elements is, once again, the juxtaposition of different temporal regimes: “The forest is slow-moving,” while “we are so short-lived.” The forester explains the short-lived nature of society through the on-demand character of contemporary life, in which everything is expected to be available within a short period of time. This perspective,

however, also presupposes that it was not always so—and that it could be otherwise. In other words, it remains open to possibility.

The cantonal government official quoted at the beginning of this section offers another interpretation of these differing temporal regimes of nature and society:

> [In the past], people have been satisfied with a protective forest for 30, 50, sometimes even 100 years. I mean, spruce trees came along, and maybe a larch tree or two. We always said, "Yes, rowan trees would be cool, but they're a problem with the game." Deciduous trees, forget them. But we still have spruce and larch. So people were satisfied with very little. And that is exactly the problem that is now catching up with us. We have actually had a problem with the forest and the game for ages. For ages, we have had certain tree species that have not taken root at all. But it worked until now because no one talked about climate change. […] And that's exactly it: we were satisfied with too little and now we're finding it difficult to get out of it because we still have a tendency [to say]: "Well, we still have the spruce." Yes, but in 2080, that's the wrong tree! And I fear that this is already the case throughout the Alpine region. We were satisfied with very little (Interview "Government employee 3(2) (cantonal)", February 2025).

This actor adopts a long-term historical perspective, explaining how society has previously adapted to the extended timeframes and relative stability of nature—an arrangement now being challenged by climate change. At first glance, this explanation appears to contradict the temporal regime described above: nature is now changing rapidly due to climate change, while society, shaped by inertia and historical path dependencies, struggles to respond with sufficient speed.

This contradiction suggests that these temporalities cannot be understood as absolute or fixed. Rather, actors' references to time represent attempts to situate the current problem of forest adaptation within a broader social context. In this sense, they offer a form of social diagnosis—an interpretation of society itself—to explain why forestry faces the challenges it does today.

I would like to pursue this idea further by examining the possibility of identifying a social ideology, while maintaining the focus on time. Instead of merely distinguishing between timescales, I explore how temporality itself is socially produced—that is, how a particular regime or strategy for dealing with these timescales becomes structurally embedded in forest praxis.

Two interview excerpts provide a first indication of this temporal regime:

> We are good at reacting in Switzerland. We are less good at acting. When something happens, politicians are very busy. [Then] they can go and win votes again (Interview "Forester 10", October 2023).

> [A] major challenge will be to try to activate this adaptation of the forest to climate change proactively, i.e. through silvicultural measures. […] It is a political decision, a strategic decision: I try to adapt my forest proactively or I leave it to nature. And in both cases, the forest will adapt. [But] if I do it proactively, I must have clear goals (Interview "Government employee 4 (federal)", December 2024).

These statements reveal how uncertainty about the future translates into a social and political inability to take proactive measures. Proactive action requires relatively clear goals—but such clarity is lacking given the uncertainty of future developments. When reacting, by contrast—once an event has already occurred—clarity appears to exist, and political action follows. As the quote from Forester 10 particularly illustrates, this analysis once again rests on the assumption that political leaders are guided by election cycles and that, within this logic, deeper problems remain difficult to address.

Paradoxically, the short-term orientation of politics appears incompatible with the uncertainty of the future. This observation also helps resolve, at least partially, the earlier contradiction between differing timescales. Precisely because society is subject to rapid change, it tends to orient itself toward what is visible and seemingly fixed. This orientation gives rise to causal mechanisms that attempt to close off the future—and with it, the field of possibilities. Such a tendency works against forestry in the context of climate change, where uncertainty and openness are intrinsic to the problem itself.

8.3.2 Experimenting with time: The logic of scientific test plantings

One actor that has so far received little attention in my analysis is science. Science is often expected to provide reliable knowledge about the future. As already noted in Section 5.1.2, most research on forests in Switzerland is concentrated at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). A key example of research on FACC that I encountered during fieldwork is the WSL project "Test plantings of future-proof tree species," launched in 2017 and funded by the Federal Office for the Environment (FOEN). The main research question is: "Which of the tree species that are considered suitable for a location at the end of the 21st century can already thrive there today?" (Eidg. Forschungsanstalt für Wald, Schnee und Landschaft, [no date]b).

Between 2020 and 2023, 56 test sites were established across Switzerland, where 18 different tree species were planted. These are species deemed "potentially viable in Swiss forests in the face of climate change" (ibid.). The study is designed for a period of 30 to 50 years, meaning that the first comprehensive results will be available only around 2050.

The aim of these test plantings is to determine whether tree species that, according to climate models, will be suited to future site conditions can already grow under current conditions. The underlying problem is that today's climate requires trees that will one day thrive under a different, future climate. In other words, species capable of tolerating both climatic regimes are needed. Accordingly, researchers are searching for species whose genetic and morphological structures enable them to withstand climatic variability. By focusing on such structures, science attempts to bridge the temporal gap: the openness of the future is partially constrained by identifying traits that can endure both present and future contingencies.

Although only two test plantations have been established in Upper Valais, the project has generated local interest—alongside certain tensions:

> And you already know about the WSL experiments. They are experimenting with different tree species and so on. But the time frame is the big problem. By the time the results from the test areas come in, you will already have had to implement various measures for a long time. [*and later in the interview*] We cannot wait until 2050 for the WSL to present its results (Interview "Forester 10", October 2023).

> There are also test tree species, the WSL network. But the findings… I am afraid they will come too late. By the time we have reliable data, we would have had to have the trees for a long time. […] When people talk about the 2080 time frame, when the models will give us certain ideas… But if I only know in 2050 [which trees thrive]! I can't convert the forest in 30 years! (Interview "Government employee 3(2) (cantonal)", February 2025).

From the perspective of these stakeholders, the problem again lies in the tension between two temporal regimes: the WSL experiments are designed to deliver reliable results over several decades, whereas in practice measures must be taken much sooner. This tension can be summed up in a question I heard from a public audience at a project presentation (field notes, 29 January 2024): "How do such test plantings support practice when the results are only available after several decades?" The WSL scientist presenting the project appeared momentarily uncertain and could not provide a clear answer. The legitimacy of science, it seems, is called into question when it cannot directly produce knowledge useful for immediate practice.

The following forester describes this need for practical application:

> [You have to] try everything, everything. I think there's a type of ash tree somewhere in the east that people say might work. Just give it a try. But the state apparatus is so slow, it's unbelievable. And no one dares to do anything. Last week we had a seminar with […] experts […]. And these are supposedly the smartest people in the field. And I realised that when they talk, they don't know anything either. They say: "Let's see." Yes, let's see what?! How long do you want to wait and see? When you need a replacement, when these forests die, you can't just say: "Oh, now they're dead, let's see." Then you'll need another 100 years or so… That's why I think we have to do it now (Interview "Forester 3", September 2022).

The approach described here is therefore not based on certain knowledge (planting an ash tree that "might work"). Rather, it exemplifies the trial-and-error strategy—or "muddling through"—outlined in Chapter 7. However, this strategy does not appear to be accepted by political authorities, who instead appear to favour a "wait-and-see" approach. This cautious strategy is mirrored in test plantings such as those carried out by WSL.

Nevertheless, as the term "experimental test planting" suggests, these projects are essentially pursuing a trial-and-error logic. The following longer account from a forester provides insight into the issue from a forestry perspective:

> We work very closely with the WSL and so on. Really very closely. But then, when it comes to the results… On the front line, I have to say, we can implement very little. I can

> give you an example. Ten years ago, I was at the university in Zurich [for a conference]. […] Great lectures, I learned a lot. At the end, there was a question-and-answer session. There were a lot of people there. I raised my hand. […] I said to them: "Listen, I came to Zurich from Valais. It was really interesting for me. Now I'm going back to Valais and tomorrow I'll be standing in the forest. What am I taking with me? Very, very little." One person said that we need to do more research in order to be able to say more. That means you need more money for research, and we on the front line will still know nothing. Tomorrow, I will be making decisions for the next thirty, if not forty, years. Not everyone understood that. […] That's just how it is. I came back here and I certainly had more knowledge, but it didn't help me solve my problems. And that's actually why I went [to Zurich]. […] Just to say: all the research is certainly good, and we on the front line, as foresters, have already got the impression that a lot is being done that is not practical. […] I can give you examples where a study that was commissioned to secure a rock was more expensive than securing the rock itself. We're moving a bit in that direction today. So when I get to that point, I say, "You know what, if I'm not sure, I'll throw the money at securing it [the rock] and then it'll be safe." I think […] that those of us on the front line feel that it's being used more against us than for us (Interview "Forester 5", February 2023).

One element that becomes visible here concerns the relationship between Valais and the rest of Switzerland. As mentioned in Section 5.3.1, it is widely recognised that people in Valais tend to identify themselves as independent from "Outer Switzerland" (*Üsserschwiiz*), particularly from the urban plateau, and they generally dislike being told what to do by the national government in Bern. In this quote, Zurich—with its metropolitan area and role as Switzerland's economic centre—stands as a proxy for the rest of the country: the forester suggests that what he learned in Zurich does not apply to Valais. From this perspective, conditions in Valais are sufficiently distinctive that statements derived from a Zurich viewpoint are deemed irrelevant. Interestingly, however, although I expected such remarks about the rest of Switzerland to be more common, they appeared only rarely in the interviews. This may also relate to the fact that I myself came to Valais from "Outer Switzerland," which could have contributed to interviewees adopting a more welcoming tone (see also the reflections in Section 5.3.1).

In contrast, the relationship between Valais and "Outer Switzerland" is overlaid here by another, more central dynamic—namely the relationship between practice and science. A brief anecdote helps emphasise this point: although Forester 5 was consistently friendly during the interview, he asked me, with some scepticism, why I was conducting yet another study on "forests and climate change." This remark stayed with me for months and initially caused unease, precisely because I had not yet developed a clear sense of my research's practical value. Only later did I come to understand this moment as central to my findings, connecting it back to the quote above.

The forester's remark reflects an underlying understanding of science: he viewed me as yet another researcher who merely produces results (which, in a sense, is true) and then uses them "against practice" (which is obviously not my intention). For him, science closes off what is practically possible—for example, funds might go to studies instead of urgent field work such as rockfall protection. Although this could be interpreted as another expression of the search for financial

resources and their "efficient use" (see Section 8.2.2), the anecdote also points to a deeper issue: the institutional separation between the production of knowledge and its practical application. For the forester, daily work is not about generating more results or knowledge but about making practical decisions "for the next thirty, if not forty, years." Knowledge, in this sense, is not a prerequisite for action; rather, the necessity to act and make decisions has priority.

These experiences and references to science therefore reveal an ongoing negotiation of the trial-and-error strategy. Scientific test plantings aim to produce reliable knowledge about a future state of the world—one implicitly treated as knowable in advance. In doing so, they attempt to close the space of possibilities by uncovering deterministic causal forces in nature that should then guide practice.

Forestry, however, operates with a different kind of knowledge about the future: it knows with certainty that the future is uncertain. This awareness necessitates practical experimentation in the present. As shown in Chapter 6, such knowledge demonstrates reflexivity—a second-order perspective on one's own understanding of the world. Yet it also reflects a different conception of the space of possibility. The goal is not to narrow this space through certain knowledge of a seemingly deterministic nature, but to activate individual and collective agency—something that presupposes a partially open horizon. In this sense, forestry does not orient itself towards a seemingly predetermined future, but towards the indeterminacy of the present, which includes human action.

8.3.3 Clear images, uncertain practices: The ambivalence of modelling the future forest

Test plantations are therefore shaped by a fundamental temporal problem: reliable results will only be available in the distant future, whereas decisions are required in the present. A form of knowledge that provides information about future conditions in the present is more readily found in models. In Switzerland, alongside established climate scenarios for temperature and precipitation, projections also exist for the distribution of individual tree species (Zimmermann, Psomas, and Normand Signe, 2016; Huber et al., 2019; Zimmermann and Psomas, 2020; Zischg et al., 2021). These forecasts rely on species distribution models (SDMs), which estimate the geographical distribution of species based on environmental factors such as temperature and precipitation. They are therefore grounded in the notion of the climate envelope described in Section 6.1.2. For climate change scenarios, regional downscaling of global climate models, such as those produced by the IPCC, is used to project future range shifts of particular species. The outcome is generally presented as cartographic representations of potential species distributions, such as those shown for Switzerland in Figures 15a and 15b (pp. 212-213). These maps are also used by public administrations to communicate the effects of climate change on forests (see e.g. National Centre for Climate Services, 2021).

At the same time, such models have been widely debated within forestry science (Pearson and Dawson, 2003; Bolte et al., 2008; Hanewinkel, 2013:40–43). The central criticism is that SDMs account for only a limited set of environmental variables and their interactions, while biotic dynamics (e.g. interspecific competition) and human influences (e.g. silvicultural interventions) are excluded. In addition, the underlying climate scenarios merely represent different emission pathways and thus outline "various possibilities for climate change depending on the success of reducing greenhouse gas emissions" (Bolte et al., 2008:803). Although they "provide a useful first approximation of the potentially dramatic impact of climate change on biodiversity" (Pearson and Dawson, 2003:361), it is widely emphasised that these models must be interpreted in light of their limitations and uncertainties (Pearson and Dawson, 2003:362; Bolte et al., 2008:800).

Despite these limitations, such models are used in Switzerland—and in Valais specifically (e.g. Métral, 2015:13; Frehner et al., 2018:16)—to derive future tree species distributions. I have also used them myself as illustrative tools in public presentations of my research (see in this regard also Figure 8 in Section 5.1.2, p. 83, where I represented expected shifts in vegetation belts). Yet in Valais, these models are viewed with notable scepticism, as expressed in the frequently quoted 2015 report by a forestry engineer summarising the state of FACC at the time:

> Although more powerful computers always lead to more accurate modelling, they only provide scenarios that depend on variables such as CO_2 and are therefore difficult to predict in the long term. They also only indicate trends for a single tree species, but do not take into account the interaction between competing species or the forest climate (Métral, 2015:18).

This captures the central analytical point: models do not offer a definitive picture of the future but instead delineate a range of possibilities—"scenarios" and "trends." On the one hand, the author justifies this by referring to the indeterministic nature of certain processes (e.g. CO_2 emissions). On the other hand, the limitations also result from epistemic constraints: certain variables (e.g. the forest climate under canopy cover) could, in theory, be incorporated but are not.

Importantly, the scientists behind SDMs consistently highlight these uncertainties (see especially Zimmermann, Normand, and Psomas, 2016:7). Among foresters in Valais, however, I heard relatively little about SDMs directly. Instead, the models have entered practice through a tool frequently mentioned in interviews: the TreeApp (BAFU/WSL, 2022). Released in 2020, this freely accessible application provides species recommendations for every coordinate point in Switzerland—one based on the current climate (1961–1990), one for a moderate climate change scenario (approx. +2°C by 2070–2099), and one for a severe scenario (approx. +4.4°C for the same period). These two scenarios are often combined into a single recommendation (see Figure 16, p. 214).

Its aim is to support forestry practitioners "in selecting suitable tree species" (BAFU/WSL, 2022) and thereby strengthen their capacity to act. Yet the TreeApp not only provides orientation; it also appears to generate new uncertainties:

> We don't actually know where we are. That's the problem in this scenario. Nobody knows, I've noticed that. I attended one or two conferences recently. Nobody knows, nobody has a clue. Like the new app that's available: TreeApp. If you look at that… It's possible that we'll suddenly have three degrees more here. Supposedly, then nothing grows there anymore. Or the pine trees are much higher in altitude, and there are none at the bottom. They don't know… Nobody knows (Interview "Forester 3", September 2022).

Here, the TreeApp and its scenarios are embedded in a series of references to uncertainty ("Nobody knows"). It does not appear that foresters gain greater certainty about which species to promote; rather, the prospect arises that "nothing will grow there anymore."

Other foresters use the TreeApp more concretely as a complement to the NaiS guide:

> There is an app called TreeApp. We are trying to work with it a little bit. And it is really helpful for us. My colleague who is in charge of this has been working with the NaiS folder since 2008. He received the NaiS folder and I gave him the task: "You have to learn it by heart. You have to master our part. I don't care about anything else. I don't have the time, but you have to be able to do it." We implement this consistently. And it works. […] Except for the things we have no influence over. Like wildlife, where we can't do anything. […] The second thing is simply… When there are such extreme climatic changes, there's nothing you can do. There are limits somewhere (Interview "Forester 5", February 2023).

This forester describes how the tool helps determine which species to promote in order to meet the NaiS profile. The scenarios offer a decision-making framework—"and it works." Yet he emphasises limits that arise not from the epistemological design of the models or their ontological assumptions, but from practical constraints beyond human control ("where we have no influence over"), such as game pressure or abrupt environmental changes.

Others point to additional problems:

> Well, the sessile oak always appears on TreeApp as the main tree species [for the future]. I'm just a bit… […] I can imagine that the sessile oak can withstand it [climate change] better, but I can't really imagine what the forests will look like in 50 or 100 years (Interview "Forester 4", February 2023).

> No one really knows how to approach this. There's already a lot of research, and the TreeApp provides some good pointers. But how this will actually be implemented in forestry is completely up in the air [*steht komplett in den Sternen*] (Interview "Forester 10", October 2024).

These quotes highlight the paradoxical effect of the TreeApp: on the one hand, it provides a seemingly definite image of the future, thereby closing the space of possibilities (e.g. by suggesting that sessile oak will become dominant). On the other hand, these images generate new uncertainties or contradict practicalities. Forester 4, later in the interview, notes that downy oak possesses suitable biotic characteristics but is currently "completely absent"— due to browsing pressure. Thus, certain knowledge does not necessarily translate into certainty in practical implementation.

Not all foresters were familiar with the TreeApp. When I explained it, their reactions revealed clear scepticism toward science. Forester 6, already doubtful about climate change, responded: "I see… after me, the computer is telling me what to do. Now it's still my turn" (February 2023). This reflects a concern about losing agency to computater. Another forester expressed himself more ambivalently when I asked about the TreeApp, which he did not know at that point:

> Okay, I'm interested. Well, obviously, it's been my job for a long time, so I… But the [scientific] studies, that kind of thing… No, I'm not really interested. If it's simplified, if it's in a newspaper […, then] I'll read it, but I won't go looking for more information. We are people who work in the field, we look at what's happening on the ground and we compare it to what we've seen over the years. It's not quantifiable, it's intuition, impressions, a vision. It's based on how you see things, reality (Interview "Forester 8", March 2023).

His contradiction ("I am interested" vs. "I am not interested") reveals an ambivalent relationship to scientific knowledge. He does not reject science outright, but personal experience, intuition, and vision take precedence, while scientific projections play a marginal role.

This reveals a dualism between science and practice—similar to the dynamics around test plantings. Here, however, the tension arises not because scientific results arrive too late, but because the statements produced by the models introduce new uncertainties or contradict practical possibilities, thereby foreclosing them.

Paradoxically, it is the seemingly reliable images of the future produced by these models that play a central role. Although the TreeApp includes a disclaimer—"It cannot be ruled out that following the recommendations may result in failure" (BAFU/WSL, 2022)—this uncertainty is not visibly integrated into the maps or recommendations. Instead, they produce a clear vision of the future (Traber and Detten, 2020; Lauser, 2024), built on a simplified causal chain linking climate change to future species occurrence.[64]

This raises the broader question of how uncertainty and complexity can be represented visually. The TreeApp uses up to three different tabs—one for the historical climate and two for future RCP scenarios—yet these still present seemingly definitive statements. Uncertainty becomes a matter of choosing between different climate futures, reduced to two scenarios. These representations, intended to make the future more tangible, instead generate new questions for foresters.

As with test plantations, the maps produce ambiguity in what appears to be reliable knowledge about the future forest. At the same time, this raises the question of where the underlying impulse to close the future actually comes from—a question I turn to in the next section.

[64] The same can, of course, also be said about the maps of projected vegetation-belt shifts that I produced in Section 5.1.2 (see Figure 8, p. 83), and about climate projections more generally. My aim in that section was not to reproduce a clear and unequivocal picture of the future but rather to emphasise the magnitude of the changes expected. Nevertheless, this serves as a reminder that representations of phenomena are never neutral and may themselves exert causal influence on how futures are imagined.

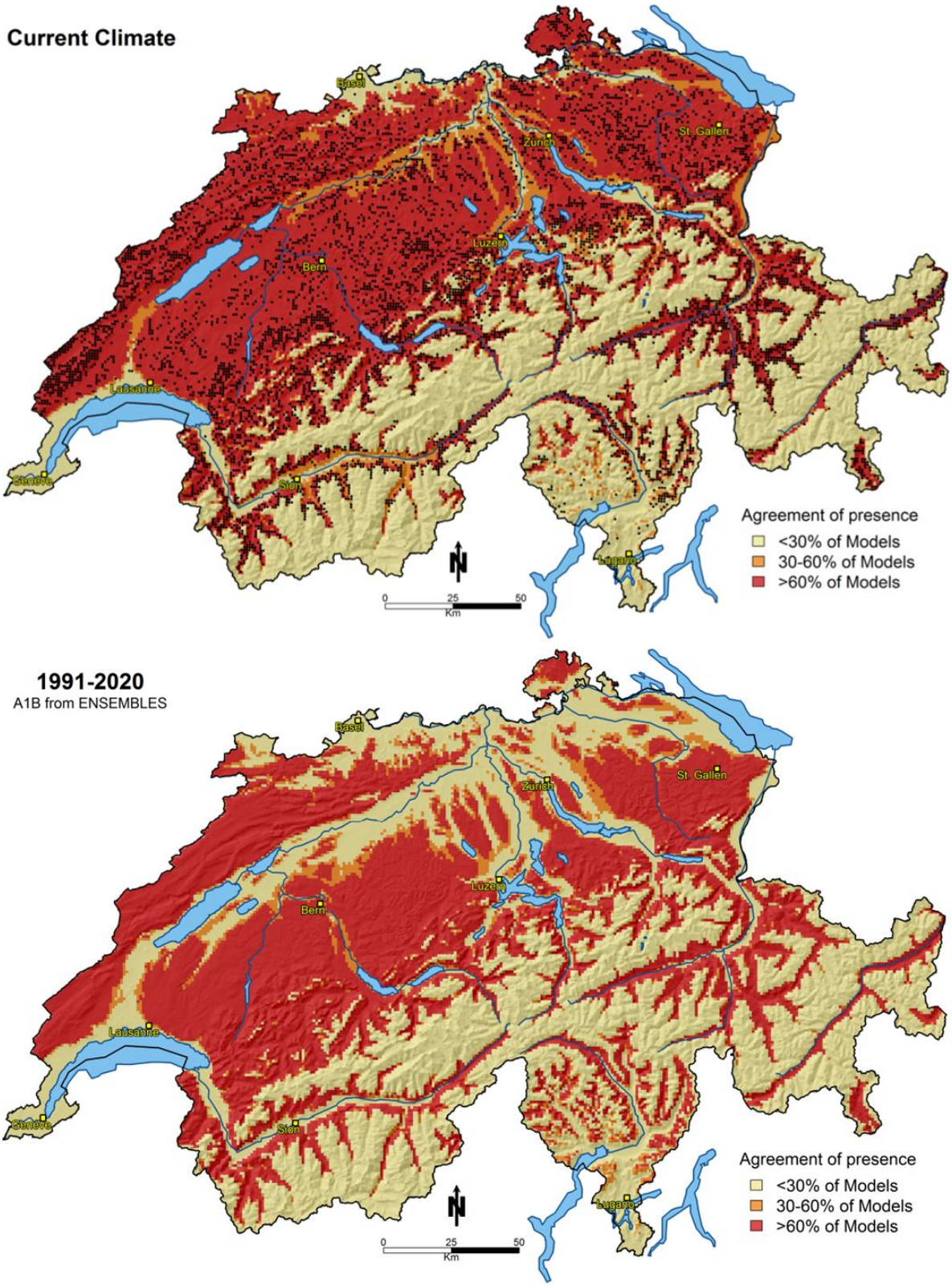

*Figure 15a: Modelled habitat suitability for spruce (*Picea abies*) based on multiple models (six regional climate models combined with six species distribution models) under the IPCC A1B scenario (approximately 3 °C global warming by the end of the century relative to 1980–1999). Red areas indicate model agreement above 60%, orange areas 30–60%, and beige areas below 30%. Black dots on the "Current Climate" map represent observed occurrences of the species (Source: Zimmermann and Psomas, 2020; see also Zimmermann, Psomas, and Normand Signe, 2016).*

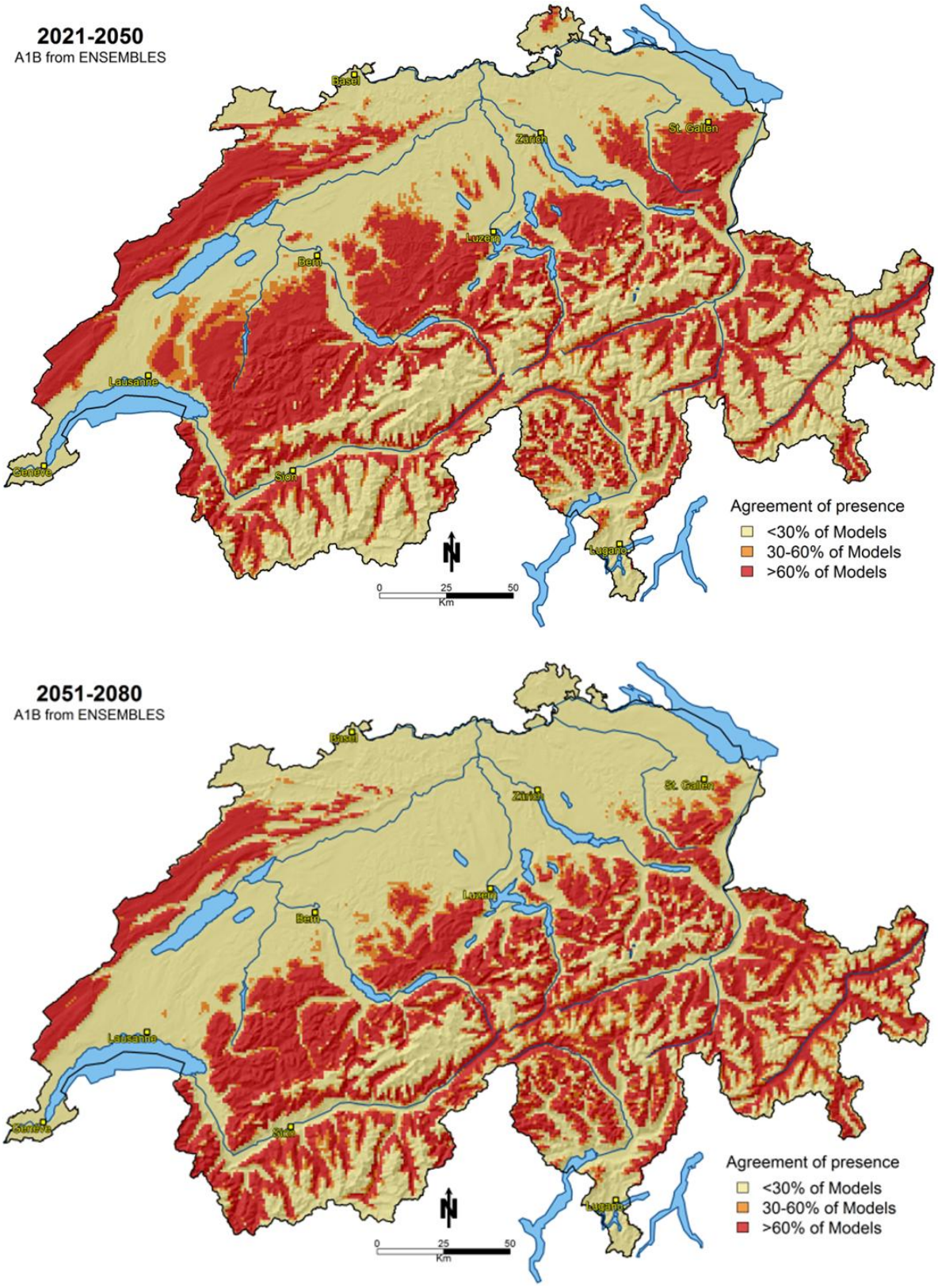

*Figure 15b: Modelled habitat suitability for spruce (*Picea abies*) based on multiple models (six regional climate models combined with six species distribution models) under the IPCC A1B scenario (approximately 3 °C global warming by the end of the century relative to 1980–1999). Red areas indicate model agreement above 60%, orange areas 30–60%, and beige areas below 30% (Source: Zimmermann and Psomas, 2020; see also Zimmermann, Psomas, and Normand Signe, 2016).*

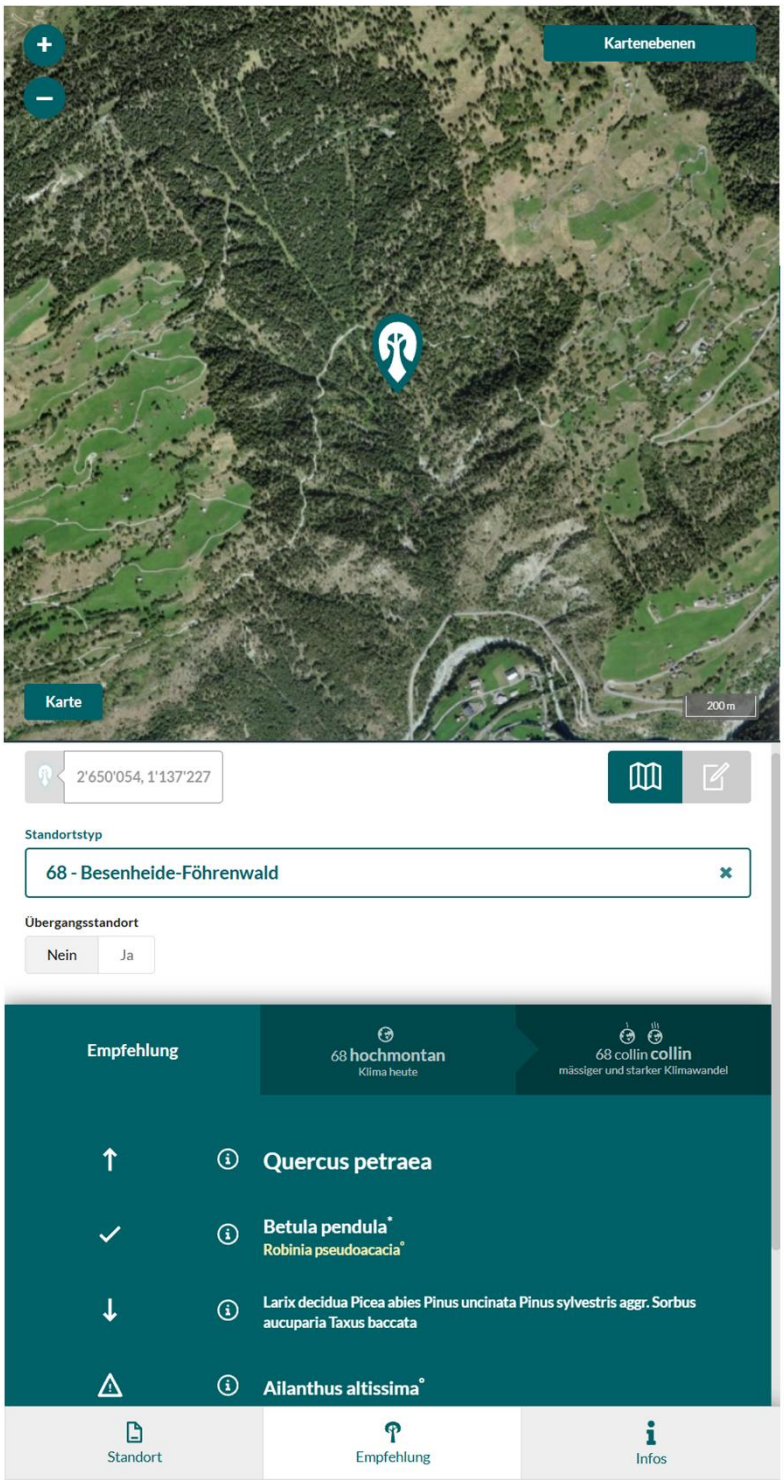

Figure 16: Excerpt from the TreeApp interface for a forest location in Valais. The site type ("Besenheide-Föhrenwald," heather-pine forest) was identified by the author based on field experience and may not be entirely accurate. An upward arrow indicates recommended future tree species (here sessile oak, Quercus petraea*); a tick marks conditionally recommended species; a downward arrow indicates threatened species; and a warning triangle denotes undesirable invasive species. The tabs "hochmontan" (high montane) and "collin" (colline) display dominant tree species under current and projected climate conditions (Source: BAFU/WSL, 2022, slightly modified by the author).*

8.3.4 Sustainability as closure: Standardising forestry under uncertainty

In the preceding sections, I have repeatedly shown how adaptation in forestry is embedded in broader social expectations. But what, more concretely, does society expect from forestry? A first indication emerges from the many practice- and policy-oriented publications in this field. These documents typically begin with formulations such as: “Silviculture should guide forest development in such a way that the forest can optimally fulfil the services required of it” (Allgaier Leuch et al., 2017:1, similarly Bundesamt für Umwelt BAFU, 2021:8; Bundesrat, 2022:3; Frehner et al., 2024:6; Schweizerische Gebirgswaldpflegegruppe et al., 2024).

This normative expectation is also codified in law. The Swiss federal and Valais cantonal forestry laws state, respectively:

> Forests are to be managed in such a way that they can fulfil their functions permanently and without restriction (sustainability) (Bundesversammlung der Schweizerischen Eidgenossenschaft, 2025:Art. 20.1).
>
> Forests are to be managed sustainably using natural silviculture methods to ensure that they can fulfil their functions in their entirety (Grosser Rat Kanton Wallis, 2023:Art. 32.3).

It is unsurprising that legal texts speak in terms of necessity rather than possibility—that is their purpose. More revealing is the way these necessities are anchored in the concept of sustainability. As discussed in Section 2.1, sustainability has held a privileged place in forestry for centuries. Yet in these legal formulations, the concept appears in an unusually open and diffuse manner: it defines a general obligation, but not the concrete practices required to meet it.

More operational guidance is offered in the *Sustainability and Performance Monitoring in Protective Forests (NaiS)* guide (Frehner et al., 2005, 2024), frequently cited throughout this chapter. First published in 2005, the guide was intended as a “practical tool” to “ensure a sustainably effective protective forest with as little effort as possible” (Frehner et al., 2005:12). It is not concerned with designating protective forests, but with maintaining them. The premise is that appropriate maintenance can produce a forest structure that minimises the risk of damage.

Central to the guide are “requirement profiles”—target conditions for the forest roughly 50 years into the future. These include characteristics such as species composition or regeneration dynamics. Importantly, NaiS does not prescribe measures; it prescribes objectives. The required forest condition is defined as one that guarantees protective effect at a given site. A distinction is made between a minimum and an ideal target, differentiating between the minimum necessary and the maximum possible protective effect in order to allow a certain scope for action. Practical measures—primarily thinning to promote diverse natural regeneration—are derived from these target states. Ultimately, success is evaluated through a system of “performance monitoring” (*Erfolgskontrolle*). Forestry practitioners must document how their interventions have affected the stand, while cantonal and federal authorities conduct random checks to determine whether the

objectives—specifically the "ideal forest condition"—are being achieved (Frehner et al., 2005:26–27).

The entire instrument rests on the premise that "in subsidised protective forest management, the implementation of measures must be controllable and the effectiveness of the measures must be verifiable" (Frehner et al., 2005:26). This is justified by the claim that "public funds [...] must be used as efficiently and effectively as possible" (Frehner et al., 2005:14). NaiS thus reproduces the efficiency principle discussed earlier (Section 8.2.2) and reflects the fact that protective-forest measures are predominantly financed by public funds.

Yet, as shown in Section 8.2.2, the uncertainties inherent in climate change make strict adherence to this principle difficult in practice. This difficulty is already visible in the original 2005 NaiS version, where climate change appears only once—mentioned alongside the "natural dynamics of our forests" as part of an area of uncertainty that complicates the measurement of success (Frehner et al., 2005:28). Addressing this uncertainty is described as a "task for research" (ibid.), which reinforces a division between practice and science, as analysed in the preceding sections.

Although many foresters use NaiS profiles, several voiced criticisms in interviews:

> Nature doesn't conform. It just doesn't. [...] It's also interesting that you have areas in NaiS where there is nothing [not the trees] that is listed in NaiS. That's just the way it should be. As soon as someone says to me, "There are pine trees there, and they're in the wrong place," then I start to think... They've been there for 50 years! And then someone [NaiS] comes along and says, "They're in the wrong place. They shouldn't be there. There should be spruce trees there." Just follow nature's example and you can't go wrong (Interview "Forester 6", February 2023).

Here, the forester argues that NaiS is insufficiently precise and that his own experience-based approach aligns more closely with nature—consistent with his broader scepticism about climate change and his view that it primarily serves as an additional avenue for governmental interference.

Another forester raised a more fundamental concern:

> [In NaiS] you always have to determine the forest communities and then you note down the forest community and then you are given a profile that you can use as a guide. But this profile is the current state of the forest community, and in 50 years' time it will be different. And then you have to apply this to the new forest community when you intervene. And that's not so easy. [...] If I do something at 1,600 metres above sea level, I have conifers, maybe a few rowan trees, whitebeams or whatever. And that's all I have. And the [NaiS] profile tells me that sessile oak will grow there. You know? [...] You have to introduce it. Nature doesn't do that. We don't have any (Interview "Forester 7(2)", October 2024).

This critique differs from that of Forester 6. Forester 7 does not dispute the relevance of either the current forest state or the future one defined by NaiS. Instead, he highlights a structural gap: the present forest lacks the elements (e.g., seeds or a regeneration layer of sessile oak) required to move toward the prescribed future condition. These elements must be introduced through human

intervention and protected from browsing. In other words, the transformation needed for climate-adapted forests is not fully captured by the existing NaiS logic.

This critique was partially addressed in the revised 2024 NaiS version.[65] Climate models and their implications are now incorporated, with "climate change" appearing 16 times and "climate" 38 times.

The new edition introduces the concept of integral risk management, defined as:

> a holistic concept for the sustainable management of natural hazards and encompasses the following tasks and activities: The periodic recording of risks ("what can happen?"), their assessment in terms of acceptability ("what is allowed to happen?") and, based on this, the need for action and priorities in order to manage risk development through measures ("what needs to be done?") (Frehner et al., 2024:9).

This sequence of questions presupposes a particular understanding of practice. Although "what can happen?" appears to denote an open field of possibilities, the guide implies that this field can be recorded and stabilised in the form of known risks. This presumed space of known possibilities is then normatively narrowed through the question "what is allowed to happen?", which relies on socially defined values. The final question—"what needs to be done?"—transforms practice into a matter of necessity rather than judgement.

This conception of practice diverges significantly from the reflexive "muddling through" described in Chapter 7. Forestry is portrayed as a domain governed simultaneously by natural mechanisms and by stable societal objectives, leaving limited room for improvisation or adaptation beyond the predefined framework. NaiS thus illustrates how the scope of action in forestry is narrowed through standardisation. Similar tendencies appeared in other moments of research: at a public event where the "need for proactive action" was discussed and "financial subsidies as a central lever" for such action identified (field notes, 14.11.2023; see also Schulz et al., 2023); or in the political use of indicators—defined as "simple, measurable parameters for complex issues, systems or processes" (Bundesamt für Umwelt BAFU, 2021:55, see also pp. 50-53)—intended to "observe and record the development of [the forest's] objectives and to review the effectiveness of the measures taken" (Bundesrat, 2022:49). Or, as a FOEN employee told me in an informal conversation: "It's tricky to talk about events that haven't happened yet" (field notes, 1 October 2025), implying that proactive measures are difficult to legitimate when they remain in the realm of the merely possible.

Statements like these rest on two assumptions: first, that practices and decisions in the context of FACC follow relatively linear causal chains; and second, that contexts of action can be reduced to a limited set of measurable parameters. The concept of sustainability, introduced at the beginning of this section, functions as an ideological foundation for this logic. The protective forest

[65] I have so far focused on the 2005 version, because it was in force during most of my interviews with foresters.

must be secured for the future—hence the present is rendered calculable, controllable, and, in principle, guaranteeable.

Section 8.3 has thus shown how a socially dominant regime of time and temporality subjects the scope of possibilities for individual forestry practice to mechanisms of closure. The short-term orientation of political decision-making, together with the fast pace of contemporary society, focuses on making certain states tangible and fixed in the present or near future, thereby undermining the societal acceptance of long-term thinking in forestry and the uncertainty that accompanies it. Scientific approaches such as test plantations and future modelling likewise follow a logic of making the distant future tangible and closed, yet they also open new spaces of possibility—and thus new uncertainties—in practice. Ultimately, a political discourse of efficiency and verifiability, supported by the concept of sustainability, suggests that the future can be controlled from the present. In forestry practice, however, this discourse produces new contradictions.

8.4 Conclusion: The emergence of actualism

In this chapter, I examined how knowledge and practice within a world of ecological change are embedded in a social context—a social *we*. The analysis focused on the social conditions into which individuals such as foresters are "thrown" when entering the profession, and on how these conditions shape knowledge and practice by simultaneously opening and constraining their field of possibilities.

The analysis of negotiations and struggles surrounding the question of nature demonstrates how FACC becomes politicised. This politicisation generates divergent—and at times conflicting—positions that translate into overt political struggles between groups of actors. From a forestry perspective, however, clearly articulated controversies—such as those surrounding wild game or the management of Robinia—appear to produce less uncertainty than the latent questioning of dominant discourses, particularly those concerning natural regeneration and the preservation of protective forests. While these discourses aim to stabilise practice through uniform frameworks, they simultaneously narrow the space of possible futures.

The chapter also showed how the forestry sector seeks to legitimise the issue of forest adaptation within the wider public. In this search for recognition, the primary aim is neither to prove the existence of climate change—already broadly acknowledged—nor solely to secure additional financial resources. Rather, foresters understand themselves as bearing responsibility toward society due to the protective functions of forests. Yet the answers required to fulfil this responsibility remain unclear. Responsibility thus becomes the dialectical counterpart to legitimacy: uncertainty about what responsible action entails generates the need for social recognition.

Turning to temporality, the analysis demonstrated how political guidelines and scientific practices contribute to an overarching impulse to render the future tangible. Short-term political orientations, the accelerated pace of society, scientific tools such as test plantings and modelling, and the efficiency-driven logic embedded in sustainability strategies all impose moments of closure on the future. These tendencies stand in contrast to local knowledge and practice, which operate with—and depend upon—the openness of the future. While foresters' actions are guided by the certainty that "things will certainly be 'different' in the future" (Detten, 2018:189), scientific and political discourses imply that the future is knowable, predetermined, and therefore controllable.

A paradox runs through these dynamics: the more strongly social and political systems insist on unambiguity—whether through the discourse on natural regeneration, protective forests, or predictive knowledge—the more the future appears to open up from the perspective of practical forestry, thereby producing uncertainty.[66] A socially dominant zeitgeist oriented toward closing the future thus collides with the reflexive awareness of uncertainty described in Chapter 6 and the practical "muddling through" outlined in Chapter 7.

From a critical-realist standpoint, this zeitgeist can be understood through the concept of *actualism*: the assumption that all processes in reality occur on a single, current level and can be fully understood and explained at that level (Bhaskar, 1978:63–142; Hartwig, 2007b). Within such a flattened ontology, the possible collapses into the actual—what could be is reduced to what is. This perspective privileges the visible, measurable, and present, thereby becoming a structuring condition of practice. It obscures the interplay of deeper, stratified causal powers in both nature and society and negates the underlying space of possibility that conditions practical agency.

By contrast, foresters' reflexive knowledge of uncertainty and their practical "muddling through" testify to the depth of the world and the reality of the possible. This space of possibilities is not merely projected into the future; it emerges in the present. Decisions must be made now on the basis of experiential knowledge of the past, coupled with the awareness that such knowledge may not hold in the future. Acting under these conditions presupposes a reflexive openness to the unknown.

Seen in this light, the social critiques voiced by foresters—such as calls for legitimacy or tensions between science and practice—can be interpreted as forms of resistance to a socially dominant actualism. Actualism leaves little room for thinking in terms of the possible; instead, it imposes seemingly unambiguous norms, reflected in notions such as sustainability and efficiency, that presuppose certainty about knowledge, practice, and ultimately the biophysical world itself.

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[66] Although this paradox resonates with an argument developed in *We Have Never Been Modern* (Latour, 1993), the affinity lies primarily at the level of form rather than theoretical alignment. Latour shows that modern attempts to separate nature and culture simultaneously generate hybrids; similarly, contemporary efforts to stabilise and render the future knowable produce new forms of openness and uncertainty.

Chapter 9: Conclusion

This chapter outlines the line of argument developed on the basis of the analysis of forest adaptation to climate change (FACC) in Valais. It begins by revisiting the research interest formulated at the outset of this thesis and by synthesising the central findings from Chapters 6–8 (Section 9.1). The chapter then turns to the broader implications of these findings beyond the specific case study. These implications are discussed, first, with regard to forest management (Section 9.2), second, in relation to human–nature relations (Section 9.3), and finally in terms of a philosophical critique of modern society (Section 9.4).

9.1 Synthesis of insights: The emergence of the possible forest

In this thesis, I have examined contemporary environmental change through the case of forest adaptation to climate change, a context in which a fundamental problem becomes particularly visible: society—and especially individuals embedded within it, such as foresters—faces long-term transformations of forests that can only ever be grasped from a limited moment in time. At the same time, these individuals, understood within complex socio-ecological systems, exert causal influence on the very transformations they seek to understand and manage. I approached the resulting questions concerning human–nature relations, temporality, and the situatedness of knowledge from a critical realist standpoint.

A central outcome of this perspective is the identification of *the possible* as a concept capable of interpreting humans' relation to a changing world. I operationalised this concept by distinguishing three dimensions from the standpoint of a knowledgeable and active person: possibilities in the (biophysical) world, possibilities in one's knowledge of that world, and possibilities in one's capacity to act within it. These dimensions guided my empirical study in the Swiss canton of Valais, based primarily on an abductive analysis of interviews and complemented by documents and observations. Through three analytical lenses, I examined how the possible forest emerges in the context of FACC: first, through knowledge as a way of rendering a changing world tangible; second, through practice as a normatively oriented intervention; and third, through socio-political relationships as conditions shaping both knowledge and practice.

With regard to knowledge about nature, I showed that both certainty and uncertainty play a role in making the future intelligible, most notably through the certainty of change itself. While scientific approaches often attempt to imagine the future as a constant conjunction of events, I found that several elements undermine such linearity—most prominently the pervasive use of conditional if-clauses. References to the possible become even more pronounced in foresters' accounts of the future forest, where attention is drawn both to multiple potential states of the biophysical

system and to the limits of knowledge about it. I then turned to how foresters refer to events they have directly experienced—whether already occurred or ongoing—and how they connect these to changes attributed to global warming. I showed that events such as the dieback of particular trees are causally linked to extreme weather, yet that such interpretations become more difficult in the case of gradual processes like long-term tree decline or bark beetle infestations, thereby opening a space for reflection. With regard to the future, succession theory—the prevailing framework for understanding forest responses to changes in the abiotic environment—provides grounds for seemingly certain accounts of the future forest while simultaneously raising open questions, as the altitudinal succession of trees does not seem able to follow the pace of rising temperatures. In this context, uncertainty is largely experienced as troubling and even paralysing, but moments of surprise and hope also emerge.

In sum, Chapter 6 demonstrated how uncertainty arises both from references to an indeterminate natural world—something external to and exceeding the knower—and from reflections on the limits of one's own knowledge. Both dimensions are central in a situation marked by the absence of secure knowledge about the complex forest ecosystem and its future development. Accordingly, rather than treating uncertainty simply as the opposite of certainty, I argued that it becomes a form of knowledge in its own right, giving rise to what I termed *reflexive* or *known uncertainty*.

In a similar vein, I examined how foresters in Valais reflect upon their own role as active agents who intervene causally in the world. The long-standing idea that humans and nature have co-shaped the landscape of Valais plays a central role here, often articulated through the notion of the "cultural landscape." Under conditions of climate change, this understanding translates into a practical strategy centred on promoting natural diversity, for example through plantings. Yet I found that efforts to do so continually encounter resistance from nature itself—through extreme drought, the invasiveness of certain species, or wildlife browsing. In this context, the self appears both insignificant in relation to long natural timescales and yet bound by the practical necessity that "things must go on." Thus, even though the future appears uncertain and practical measures often follow a trial-and-error logic whose outcomes may remain unclear, inaction is not considered a viable option.

Accordingly, Chapter 7 described the role of foresters as one defined by the continual redefinition of problems, practical possibilities, and normative goals, ultimately revealing their embeddedness within the world they seek to manage. Because this role—much like knowledge and uncertainty in this case—is actively acknowledged and reflected upon, I characterised forest adaptation practice as a form of *reflexive "muddling through"*.

Finally, I investigated the social conditions within which these forms of knowledge and practice operate, revealing how FACC becomes politicised in Valais. Paradoxically, however, I found that highly politicised issues—such as game management or the handling of Robinia—tend to generate fewer uncertainties in forestry practice than dominant and socially stabilised discourses on

natural regeneration or protective forests. At the same time, the forestry sector seeks legitimacy not only for recognising climate change or securing additional financial resources, but above all for the responsibility it bears towards society in the context of protective forests—an issue to which no clear answer may be possible under conditions of persistent uncertainty. Yet the idea that such answers exist and must be provided is continually reproduced through societal requirements: the temporal logic of political electoral cycles, scientific instruments such as test plantings and models, and a sustainability discourse grounded in calculation, standardisation, and control, exemplified by the NaiS framework.

In Chapter 8, I synthesised this dominant zeitgeist under the term *actualism*—a focus on the immediately given that collapses the space of the possible into the present. Within such a flat ontology, the visible, the measurable, and the present are prioritised over an acknowledgement of deeper, stratified causal powers in the relationship between nature and society that are not immediately accessible.

As a result, I argue that forms of knowledge and practice that rely on openness toward the future come into tension with social expectations oriented toward its permanent closure. Paradoxically, it is precisely this contradiction—this clash of opposing causal forces—that produces uncertainty and gives it practical significance: the greater the pressure to determine and stabilise the future, the more open questions and divergent pathways arise in forestry practice, for example when site conditions do not align with NaiS profiles, when practical implementation is delayed in anticipation of more precise knowledge, or when modelled future conditions lead to practical impossibilities. Hence, foresters—who know the world as and act within a field of possibilities—are continually confronted with a social demand to subject this field to closure.

This brings me back to the question raised in Section 4.3.2: *how does the possible forest emerge?* While numerous biophysical, epistemic, and individual forces—and the relations between them in practice—shape this process, the central insight can be summarised as follows: *paradoxically, it is the socially imposed demand to close the space of future possibilities that ultimately opens it up*.

With regard to the overarching research interest—how to engage with change in complex socio-ecological systems from a position within that change—I therefore conclude that change gains its significance precisely when it is confronted with countervailing tendencies toward stabilisation and preservation.

9.2 Contributions to forest management: Rethinking knowledge, practices and policies

What do these findings mean, and how do they contribute? As a first step, I discuss their relevance for forestry—both in Valais and beyond—and for its broader socio-political context.

The results speak to several ongoing debates within forestry and forest science. The issue of *wildlife and browsing*, for instance, is increasingly addressed in ecological research (for an overview, see Hardalau et al., 2024), yet it has so far received comparatively little explicit attention from the social sciences. Although not the primary focus of this study, the importance that Valais foresters and other actors attribute to browsing highlights the need for more sustained examination. My findings suggest that this debate cannot be reduced to the question of increasing culling quotas for browsing hoofed game. Rather, it is interwoven with historically shaped predator–prey relations, cultural traditions, and associated political controversies—particularly the ongoing debates surrounding wolves in Switzerland.

A similar pattern emerges with regard to *non-native or invasive species*. Although scientific research on this topic is extensive (see Wohlgemuth et al., 2022, for an overview), social science perspectives remain rare. Where they do exist, natural science categories (e.g., non-native, invasive) are often adopted uncritically (see, for example, Pötzelsberger et al., 2020; and for Switzerland, Junge et al., 2019; Genazzi et al., 2022). However, as the example of Robinia in Valais demonstrates, such classifications are neither the sole nor the central factor shaping practical management decisions. Instead, these categories frequently generate contradictions within and between actors, thereby reinforcing existing uncertainties. This finding resonates with work such as Wollrath (2022) in forestry and Boonman-Berson et al. (2014) or Fall (2013) beyond forestry, all of which argue that the ambiguities and contested meanings of such classifications require deeper analysis attentive to normative, political, practical, and discursive dimensions.

Regarding the general orientation of *forest-management strategies for climate adaptation* (Lindner et al., 2014; Keenan, 2015; Vacek et al., 2023), this study shows that such strategies do not simply rest on scientific "facts." Although natural regeneration as a means of promoting diversity appears widely accepted and scientifically supported in Valais and Switzerland, decisions are shaped just as strongly by practical considerations, including financing, workload, and negative experiences with alternative strategies such as planting. Despite broad support for natural regeneration, several challenges persist, including wildlife browsing and the comparatively slow spread and adaptation of relevant species relative to the pace of climate change.

Particularly with regard to the latter, new approaches such as assisted migration of tree species or assisted gene flow are increasingly discussed in the literature (e.g., Aitken and Bemmels, 2016; Peterson St-Laurent et al., 2018). While such ideas are acknowledged in Valais—for example

through isolated plantings or the direct sowing of new species or provenances—they are rarely pursued as large-scale strategies due to practical obstacles such as costs, workload, and the need for browsing protection. This again illustrates how strategies presented by science as discrete and actionable often compete with a multitude of practical and political considerations. Ultimately, individual and contextual factors determine which strategy is implemented.

With regard to the *social functions* forests are expected to fulfil—and the relative weight these functions assume in forest practice and politics—this case study reveals a comparatively clear hierarchy: the protective function takes precedence over all others, including resource use, conservation, and recreation. In contrast to debates in Germany and other EU countries—where political conflicts between different forest functions are central (e.g., Winkel et al., 2011; Koning, Winkel et al., 2014)—the key issue in Valais is how the imperative of maintaining protective forests structures the entire discussion on climate adaptation. Knowledge about the "forest of the future" reflects this political priority: perspectives deemed irrelevant or impractical (such as knowledge emphasising uncertainty) tend to be marginalised (for similar dynamics in ecosystem-services debates, see Turnhout et al., 2013). As this study has shown, there are indeed voices that question the supposed inevitability of maintaining protective forests—whether because of costs, labour demands, or the recognition that the loss of protective function is itself a possibility—but these voices are largely drowned out. This suggests that discussions not only about forest functions but also about the consequences of their potential loss should feature more prominently in both public debate and scientific research.

Turning to *uncertainty*—the central theme of this thesis and a major topic in forestry scholarship (e.g., Hanewinkel, 2013; Lindner et al., 2014; Detten and Hanewinkel, 2017; Yousefpour et al., 2017)—my findings indicate that uncertainty does not derive solely from the indeterminacy of the future or from incomplete knowledge. Equally important, if not more so, is the socially and politically imposed demand to grasp, determine, and control the future. Foresters and other interviewees appear well aware that not everything can be known or controlled and reflect explicitly on this condition. Their practical strategies are grounded less in certainty than in a conscious engagement with uncertainty, resulting in a form of reflexive or intelligent "muddling through" (Detten, 2011, 2018). Interviewees from academia and public administration likewise acknowledged that uncertainty cannot simply be eliminated through additional knowledge or more precise guidelines.

This raises the question of how to explain the discrepancy between the individual recognition of uncertainty—as expressed in interviews—and the societal tendency toward control, fixation, and the closure of possibilities that characterises institutionalised contexts, most visibly in official documents. One possible explanation lies in the composition of the sample of this study: individuals open to critical reflection may have been more willing to engage with a social scientist than those more strongly oriented toward established procedures and certainties. The exploratory

approach adopted here could therefore be extended—for example, by examining how practitioners actually use tools such as NaiS in their daily work through go-along interviews or participant observation.

Another avenue would be to organise focus groups with foresters, administrators, scientists, hunters, or local residents in order to explore how control over nature and openness to the future are articulated in collective discussion. It would also be valuable to study more closely the production and negotiation of forest climate models within forest science, examining how uncertainties—and an associated space of possibilities—emerge within these processes. Such approaches would place greater emphasis on interdisciplinarity and on the co-construction of knowledge with actors from the field. I deliberately set aside this avenue in the present study in order to focus on identifying the deeper structural dynamics shaping the case of Valais.

At the same time, I locate this tendency toward closure at a level that transcends individual actors, since agency is clearly constrained by broader structural forces. The remaining two sections of this conclusion therefore examine, in a more diagnostic and interpretive manner, these underlying structures—described in Chapter 8 as an emerging "zeitgeist"—first through the lens of evolving human–nature relations and then through the philosophical discourse that underpins them.

9.3 Contributions to human–nature relations: Rethinking assumptions, limits and possibilities

In this thesis, I have not understood forests as ecosystems emerging solely from abiotic and biotic causal powers. Rather, I have emphasised that—particularly under conditions of climate change—social forces must be incorporated into any adequate understanding of such systems. From a practical perspective, this includes the agency of human individuals as well as the social structures in which they are embedded—and which they simultaneously (re)produce. While the terms "human" (or "society") and "nature" retain analytical distinctions and heuristic value, human and non-human elements ultimately form part of a single, interconnected system (see especially Section 4.2.1). Contemporary forests emerge precisely through this relationality, mediated by knowledge and practice. Even though—or precisely because—concepts such as natural diversity and natural regeneration play a central role in practice and politics, the case of Valais, with its centuries-old tradition of protective forest management, vividly illustrates this entanglement of human and natural processes.

As a starting point for the analysis, I focused on knowing and acting individuals—foresters—but then followed a series of abductive and retroductive steps to examine the social conditions that structure, or at least seek to structure, their practices and the resulting human–nature relations. Central to these dynamics is the challenge of *dealing with uncertainty and an open future* (Wynne,

1992; Uekötter and Lübken, 2014; Scoones and Stirling, 2020). Indeed, the socially dominant approach to forest management in the present case lacks a fully adequate way of engaging with these conditions, as it tends to seek their elimination. Yet, as Detten (2011:458) notes, uncertainty and "muddling through" are not new phenomena in forestry but have long been integral to forest practice. In this sense, the problem may lie less in current practice itself than in the underlying social conditions that both constrain and enable it (Detten, 2018).

This tension is evident in the empirical case of Valais. While the structures of the social system tend to pursue the elimination of uncertainty and openness through projections, experiments, and planning guidelines, forestry practitioners appear—somewhat contrary to the traditional image of long-term planning in forestry—to accept the limits of their present position in a changing world and to develop strategies for dealing with them. This challenges positivistic assumptions about the determinacy or determinability of nature and renders concepts such as a "culture of trial and error" productive beyond the level of individual practice—namely, as orientations that could be recognised and supported at the level of institutions, organisations, and ultimately society (Reinhold et al., 2025). Importantly, this is not merely about making "error" socially acceptable again, but about collectively negotiating which forms of risk and failure can and should be accepted in the first place—and under what conditions they become meaningful. In the present case, this is particularly evident in discussions about the possible loss of the forest's protective function, which implicitly presuppose the continued maintenance of the very infrastructure whose protection gives that function its significance.

These insights carry direct implications for *policies* governing ecological change, complexity, and uncertainty. Under conditions of deep uncertainty, classic governance principles—such as planning, efficiency, and regulation—prove insufficient. Yet the present analysis highlights a persistent "longing for reliable guidelines and directives that help prevent or reduce environmental problems and risks" (Detten et al., 2013:8) at the political level, even though such expectations are not reflected in practice. This points to the need for political frameworks that not only recognise but also legitimise uncertainty and forms of "muddling through" (Wynne, 1992; Detten, 2011; Reinhold et al., 2025), making them not merely "add-ons" but the "cornerstone and central tenet" of governance (Faber et al., 1992:92). Doing so requires making explicit the epistemological and ontological assumptions—and limitations—embedded in prevailing imaginaries of complex systems and the future, whether in scientific modelling, policy, or everyday discourse (O'Sullivan, 2004; Thompson, 2022; Byrne and Callaghan, 2023). In some contexts, this may also entail reconsidering seemingly rigid premises, such as the unconditional preservation of protective forests—although such reconsideration would necessarily depend on broader public debate. A strategy of climate adaptation that relies on business as usual implicitly assumes that "there is no alternative" (Roe, 2020:79–80; see also Bhaskar, 2008:108-110). Such premises constrain the flexibility,

reflexivity, and social deliberation required to engage with the multiple possibilities that the future may hold.

Within this context, *natural science* occupies a central yet not unproblematic position. The challenges faced by foresters in everyday practice do not stem from a simple lack of scientific knowledge, as is sometimes suggested in the literature on FACC (e.g., Lindner et al., 2014:80; Sousa-Silva et al., 2018:27–29; Vinceti et al., 2020:1117; Hazarika et al., 2021:11). If anything, the case study at times suggests the opposite: additional knowledge can generate new questions and thereby increase uncertainty. Efforts to produce ever clearer answers—through species trials, test plantings, or climate modelling—frequently create new ambiguities for both practice and policy (Traber and Detten, 2020; Lauser, 2024). The pursuit of increasingly precise predictions (Koning, Turnhout et al., 2014), the epistemic authority attributed to them, and the underlying "linear model of expertise" (Beck, 2011) may thus have reached their limits—not because such knowledge is false according to a correspondence theory of truth, but because it sustains a discourse that presupposes that definitive, verifiable knowledge can and should be attained (Roe, 2020). In doing so, it marginalises the recognition of uncertainty and constrains engagement with an open future. In this sense, the production of scientific facts is inseparable from the social order in—and together with—which they are produced (Jasanoff, 2004).

What is required instead are *forms of knowledge* co-produced with practitioners. This elevates the relevance of practitioners' local knowledge (Raymond et al., 2010)—although, based on the present findings, it may be more accurate to speak of local uncertainty. This is not to suggest that uncertainty is merely local, but rather to emphasise that foresters and other practitioners develop intuitive and reflexive ways of knowing and engaging with uncertainty that differ from those dominant in science or administration. Critical realism can contribute here not by disconnecting knowledge from reality, but by foregrounding its transitive and fallible character and the need for continuous critical scrutiny. Such an orientation fosters epistemic humility (Jasanoff, 2007) and opens space for reflecting on how different forms of knowledge—and uncertainty—can contribute to collective understanding. Importantly, recognising one's limited access to the world is also a position of responsibility and thus carries ethical implications (Cilliers, 2005).

The diagnoses developed in this study also call into question several dominant concepts, most notably *sustainability*. As discussed in Chapter 2, sustainability originated in forestry and has since become a cornerstone of contemporary debates on climate and environmental change (Grober, 2013). Historically oriented toward long-term resource conservation, sustainability implies a forward-looking temporal horizon. Yet in the present case, this future orientation does not yield a clear vision; instead, it opens a space in which multiple possibilities—and unexpected developments—can unfold. This shifts attention back to the present, as it is here that such possibilities must be navigated in practice. Acknowledging the limits of sustainability as a future-oriented concept (Detten, 2013; Benson and Craig, 2014), and integrating it more strongly into present-

oriented practice, may enable renewed emphasis on the capacity to navigate an ever-changing space of possibilities (Detten, 2018).

The *complexity* of contemporary environmental change makes such a return to the present necessary. On the one hand, the frequent use of conditional formulations—ifs, buts, and qualifications—in the empirical material demonstrates that biophysical processes and their management cannot be reduced to simple linear principles. On the other hand, the fact that actors continue to exert causal influence shows that complexity does not amount to radical contingency (Cilliers, 2005; Urry, 2005; Byrne and Callaghan, 2023). Resilience, in this sense, is not only a property of ecosystems but also of the human actors involved: it denotes their capacity to continually reorganise and adapt in response to unexpected change (Benson and Craig, 2014). Accordingly, the human causal powers to know, reflect upon knowledge, and rethink individual and collective practice are central to understanding such complexity. The conceptual framework developed in this study—centred on the notion of the possible—captures this dynamic by drawing attention to the interplay between structuring and changeable elements.

This dialectic is particularly evident in *human–nature relations* more generally. Nature is often approached as something to be managed or controlled—an orientation that presupposes a deterministic and actualist ontology grounded in constant conjunctions of events. Yet nature persistently resists such efforts, revealing its independence, depth, and transience (Soper, 2000). At the same time, these moments of resistance are not permanent; they open temporary spaces of possibility within which foresters can act.

Paradoxically, however, social demands and institutional structures often seek to close precisely these spaces. While environmental change is widely acknowledged, society frequently resists change itself—even though human history can only be understood through the notion of change (see Section 2.1). Acting within a space of possibilities—something individual foresters already do in practice—remains unfamiliar at the societal level and is therefore undervalued. The more society seeks to manage and control nature, the more new possibilities emerge—and the less control it ultimately retains.

From this perspective, it becomes necessary to view not only ecological processes but also the social configurations that shape them as dynamic. This entails shifting attention away from notions such as “the forest of the future.” The “sustainable forest” may be less a fixed object or endpoint toward which management converges than an ongoing process with an open outcome—one that can only be grasped as a possibility in the present. In this regard, it may be more productive to move beyond longstanding debates about the dualism between nature and society (e.g., Latour, 1993; Castree, 2014; Malm, 2019) and instead focus on the interplay between structure and openness, since it is this dualism that drives novelty and emancipation (Faber et al., 1992; Prigogine, 1997; Bhaskar, 2008; Norrie, 2010), albeit with the unavoidable side effect of uncertainty.

The conceptual framework developed in this study highlights these dynamics of opening and closing the future that underpin the notion of the possible. It reframes environmental change not merely as uncertainty about a supposedly fixed future, but as engagement with the possibilities inherent in the present. Central here is the interplay of structuring and changeable elements—located in the biophysical world, in society, and in knowledge and practice as mediators between these realms. Identifying these elements abductively in the empirical material provided insight into how a space of possibilities emerges in FACC. In this sense, the framework may also hold heuristic value for other empirical fields in which uncertainty plays a central role, such as responses to climate-related extreme events, gene editing, or artificial intelligence.

Analytically, however, separating the dimensions of this space proved challenging. In the empirical material, references to nature and to knowledge about nature were often inseparable. This may indicate that the distinction between reality and knowledge does not readily apply at the empirical level and therefore requires theoretical refinement. Alternatively, it may reflect the influence of an actualist philosophy shaping this field. From this perspective, sharpening the distinction—also in empirical work—remains important, as it is precisely here that reflexive scrutiny of knowledge becomes possible, not only individually but also societally. At the same time, this experience underscores that such conceptual distinctions should not be understood as rigid or mutually exclusive, but as heuristic tools for interpreting the empirical world.

Finally, the analysis points toward further development from the perspective of critical realist philosophy. As critical realism understands itself as an emancipatory philosophy grounded in social change and becoming (see especially Bhaskar, 1986, 2008; Norrie, 2010), these findings also gesture toward an immanent critique of contemporary society. This line of argument is taken up in the final section of the conclusion.

9.4 Contributions to a philosophical critique of modernity: Rethinking actualism, empiricism, and uncertainty

In this thesis, I have traced how the possible—here exemplified by the forest of the future—emerges, on the one hand, from a multiplicity of elements, forces, and relations as a distinct layer of reality, while, on the other hand, unfolding causal power of its own. By the causal power of the possible I do not mean a deterministic force that predetermines what must be done. Rather, the possible operates as a potential that enables practice to continue under conditions where neither knowledge nor outcomes can be secured in advance. In cases such as forest adaptation to climate change—marked by long temporal horizons and high socio-ecological complexity—this power becomes visible in acknowledged uncertainty, reflexive forms of "muddling through," and in a socio-structural countertendency to close down the future.

In this sense, I have, first, added the emergent layer of the possible to realist approaches to socio-ecological complexity and systems thinking (Mingers, 2014; Byrne and Callaghan, 2023; Price, 2023; Porpora, 2024), and shown how this layer is articulated through always-already acting subjects. Second, these empirically derived insights provide a point of departure for reflecting on deeper structures of the present world—social and natural, or more precisely, contemporary social relations to nature. Here, the (meta-)theoretical vocabulary of dialectical critical realism offers a starting point for retroductively identifying philosophical conditions of the modern world within which this case study is situated.

The empirical case shows that it is not only foresters who are aware of the limits of knowledge. Interviews with scientists and government officials likewise revealed that prevailing approaches to forest adaptation are being critically reassessed in light of uncertainty. This raises a central explanatory question: what counteracts such reflexive individual agency, and how can this tension be understood? As my analysis suggests, the relevant force can be conceptualised as a social structure, ideology, or zeitgeist—captured in critical realism through the concept of actualism: the assumption that only what is actual is real, and that reality is exhausted by what is given, thereby foreclosing openness and possibility (Bhaskar, 2008:369).

Actualism simultaneously constrains the possible and gives it its significance. When environmental change is understood exclusively at the level of observable events—without recognising the plurality of causal powers located in biophysical nature, individual agency, and social structures—it is unsurprising that possibilities appear either as insurmountable uncertainty or as something that must be eliminated through closure. This helps explain why societies tend to cling to the status quo precisely in periods of profound ecological transformation.

From within such a closed system, nothing other than the present configuration of reality appears genuinely conceivable. Absences—for instance, the loss of a forest's protective function—become difficult to address, treated as unthinkable, or excluded from the realm of the possible altogether. Yet this overlooks the fact that nature and society are not independent or dichotomous spheres, but moments of a shared, open, and stratified world—one that necessarily includes absences as well as possibilities. In this sense, it becomes crucial to acknowledge that "the positive is a tiny but important ripple on the surface of a sea of negativity" (Bhaskar, 2008:4): what exists at a particular moment is only a small part of a reality in which much is not (yet) the case—and it is precisely this not-yet and not-now that grounds the possible and, with it, agency.

Only a fraction of reality is empirically accessible. Ontological actualism is therefore typically accompanied by epistemological empiricism (or positivism): the assumption that only what is accessible through sensory experience can generate knowledge, and that knowledge should correspond directly to the world—what Price (2016:116) calls the "mainstream belief that what is real is only what is empirical." In my analysis of FACC in Valais, this orientation is evident, for instance, in recurring emphasis on the visibility—or invisibility—of the problem (see Sections 6.2, 8.2, and

8.3). At the same time, my analysis showed how knowledge and reality repeatedly diverge: reality resists epistemic capture, and this resistance is reflected in what I have described as known uncertainty.

This empiricist–actualist orientation also shapes much of the scientific literature on FACC (see Chapter 2). On the one hand, biophysical nature is often reduced to general laws and universalised statements, neglecting its openness, dynamism, and complexity—alongside the equally complex and dynamic character of society, even where complexity is rhetorically acknowledged through references to complex adaptive systems. On the other hand, social "laws" are pursued through analyses of actors' perceptions, again presupposing that such laws exist and are directly observable. In both cases, reality is assumed to articulate itself transparently and to be empirically accessible in a straightforward manner. These approaches rest on a flat ontology and a correspondingly flat epistemology, and therefore fail to capture both the depth of the social and natural world and the fallibility of knowledge itself.

My own discomfort with the expectation—discussed in Section 5.3 on positionality—that my research should yield immediate practical benefits can be interpreted in this light. Such expectations presume that problems are clearly defined and that definitive solutions can be delivered. Yet the case study shows that both problem definitions and answers are often provisional, contested, and subject to revision. A central outcome of this study is therefore the recognition that dealing with uncertainty—the absence of definitive answers—is unavoidable. As Bhaskar (2010:61) puts it: "There is no necessity that the world should be knowable to us, even if it is understandable why it should seem to be so."

Actualism and empiricism can thus be understood as characteristic features of the modern temporal and epistemic order in which this case is embedded. The Enlightenment impulse to quantify, rationalise, and control nature—discussed in Chapter 2.1—appears to persist in contemporary attempts to manage forests. Within an actualist horizon there is little room for conditional if-clauses, subjunctives, or modal verbs—and thus little room for uncertainty, reflexivity, or possibility. From this perspective, the ways of thinking articulated by forestry practitioners in Valais may also be read as a subtle form of resistance to this order. In this regard, the problem of modernity may be less that it tries to separate society from nature while simultaneously producing hybrids (Latour, 1993), and more that it attempts to control the future by maintaining the status quo (Bhaskar, 2008)—reducing the possible to the merely actual and the causal to the merely empirical.

Paradoxically, an adequate response to actualism lies in attending more closely to the present. This does not mean intensifying efforts to control the future (as in positivism), nor dissolving past and future into a randomised present (as in some poststructuralist responses to positivism; see Malm, 2018:1–2). Rather, it means recognising the depth, limits, and indeterminacy of the present itself—and that this indeterminacy is a precondition for agency. In the context of climate change,

where debates often prioritise increasingly detailed representations of the Earth system, this suggests re-centering questions of value, responsibility, and action (Price, 2019, 2023). The present case therefore supports a stronger emphasis on the axiological necessity of action and on the primacy of action over the indefinite accumulation of knowledge. This also re-emphasises the role of human subjects as producers of both knowledge and action—and the contradictions and conflicts that arise from the necessity to act (a dimension sometimes identified as underdeveloped in critical realist philosophy; see Hannah, 1999:18; Brereton, 2004:273).

Temporality is crucial here. Linear conceptions of time prove inadequate when change unfolds across multiple, interacting temporal scales. In this sense, contra Harman's (2009:195–196) critique, critical realism can indeed escape linearity and mechanistic thinking. Attempts to grasp distant futures through stable causal chains not only fail but often generate new forms of uncertainty in the present. Rethinking the future not as an object to be known in advance, but as something that emerges through situated action in interaction with biophysical causal powers, is therefore more productive. Acknowledging the present as a limited and uncertain moment within an open totality also reorients society toward recognising its containment within—and dependence on—nature: "nature is not apart from us, we are a part of it. The destruction of nature is not only murder, but suicide" (Bhaskar and Hartwig, 2016:208).

In this sense, the thesis contributes to a critique not only of modernity, but also of postmodernity, by identifying in actualism a position that can underwrite both mechanistic determinism and a depthless, fluxionary view of time as mere contingency. The uncertainty and field of possibilities observed in the case can only be apprehended as real if reality is conceived as stratified—such that not everything, and especially not the causal powers governing it, exists at the level of the actual or the empirical.

This philosophical emphasis of the present work has come at a cost. By focusing on discourse and meta-theoretical structures, I have largely bracketed other social structures, such as legally institutionalised power relations or economic–material arrangements. How society might be reorganised in more concrete terms, or which institutional arrangements would enable action upon these insights in specific contexts such as forest adaptation in Valais, therefore remains an open question. After considerable reflection, I cannot offer definitive prescriptions—only orientations such as accepting uncertainty, fostering a culture of error, or foregrounding the present. This may be the most significant limitation of the thesis. Yet offering prescriptive solutions would risk reproducing the very actualism the thesis seeks to critique. Such responses must emerge within concrete situations rather than from abstract theory alone.

In the face of ongoing environmental change, this ultimately entails acknowledging that "there is no way of getting rid of change, and no way of getting rid of the fear of change except by embracing change" (Bhaskar, in Bhaskar and Hartwig, 2010:140). The changeability and complexity of the world confront us with limits and call for a sober and humble stance. At the same time, they do

not absolve us of responsibility. As the case of Valais has shown, defeatism or fatalism is not the answer—even in the face of an uncertain future. “And then it goes on,” or a “reflexive muddling through,” also means understanding the deeper causal origins of the present crisis and seeking to transform them.

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Appendix

List of interviews

The following list presents the interviews that form part of the empirical basis of this study. All interviews were conducted by the author, some in collaboration with master's students. The interviews are listed in chronological order.

Designation	*Date/location*	*Further details about the interview partner*	*Context/recording/ transcription*
Scientist 1	31.01.2022, online via MSTeams	forest scientist from Switzerland	exploratory interview for case study search (recorded, but not transcribed)
Scientist 2	06.05.2022, online via MSTeams	forest scientist from France	exploratory interview for case study search (recorded, but not transcribed)
Government employee 1	24.8.2022, online via MSTeams	two government employees from the canton of Graubünden	exploratory interview for case study search (recorded, but not transcribed)
Forester 1	11.09.2022, in a forest in Valais	forester at a forestry operation in Valais	field course with master's students, full-day walk in the forest, recorded, transcribed
Various 1	12.09.2022, at the interviewee's home	representative of a local nature conservation organisation in Valais	field course with master's students, recorded, but not transcribed
Forester 2	13.09.2022, in a forest in Valais	district forester in Valais	field course with master's students, unexpected car journey and walk to a forest, recorded, transcribed
Various 2	13.09.2022, in the office of the persons interviewed	two representatives of a forest nursery in Switzerland that supplies trees for planting in Valais	field course with master's students, recorded, but not transcribed
Government employee 2	14.09.2022, online via MSTeams	employee at FOEN	field course with master's students, recorded, transcribed (however, the person did not wish to be quoted directly)

Scientist 3	14.09.2022, online via MSTeams	forest scientist from Switzerland	field course with master's students, recorded, transcribed
Government employee 3(1)	14.09.2022, in the interviewee's office	employee at the cantonal office of forests	field course with master's students, recorded, transcribed
Forester 3	15.09.2022, in the interviewee's office	district forester in Valais	field course with master's students, recorded, transcribed
Forester 4	07.02.2023, in the interviewee's office	district forester in Valais	in-depth interview, recorded, transcribed
Scientist 4	08.02.2023, online via MSTeams	forest scientist from Switzerland	in-depth interview, recorded, transcribed
Forester 5	15.02.2023, in the interviewee's office	district forester in Valais	in-depth interview, recorded, transcribed
Forester 6	21.02.2023, in the interviewee's office	district forester in Valais	in-depth interview, recorded, transcribed
Forester 7(1)	21.02.2023, in the interviewee's office	district forester in Valais	in-depth interview, recorded, transcribed
Forester 8	09.03.2023, in the interviewee's office	district forester in Valais	in-depth interview, recorded, transcribed
Forester 9	29.03.2023, in the interviewee's office	district forester in Valais	in-depth interview, recorded, transcribed
Various 3	19.04.2023, in a café in Valais	representative of a local nature reserve in Valais	exploratory conversation (not recorded, not transcribed)
Forester 10	12.10.2023, in the interviewee's office	district forester in Valais	in-depth interview, recorded, transcribed
Forester 11	11.10.2024, in the interviewee's office	district forester in Valais	in-depth interview, recorded, transcribed
Forester 7(2)	11.10.2024, in the interviewee's office	district forester in Valais (same person as "Forester 7(1)")	in-depth interview, recorded, transcribed
Government employee 4	4.12.2024, in the interviewee's office	employee at FOEN	in-depth interview, recorded, transcribed
Government employee 3(2)	18.02.2025, in the interviewee's office	employee at the cantonal office of forests (same person as "Government employee 3(1)")	in-depth interview, recorded, transcribed

List of attended events

The following list presents the events attended by the author during the course of this research that informed the empirical analysis. The events are listed in chronological order.

***Title* (speaker)**	**Date/Location/Organiser**
Symposium: Das Klima verändert den Wald – wie weiter? (various speakers)	18.03.2022 (full day), Suhr, Naturama Aargau
FAN-Herbstkurs 2022 – Wald – Schutz und Gefahr (various speakers)	01.09.-02.09.2022 (full day), Brig, Fachleute Naturgefahren
Évolution de la gestion des forêts valaisannes de 1970 à nos jours (Roland Métral)	20.01.2023 (2h), Sion, La Murithienne
La forêt fribourgeoise face au changement climatique (Frédéric Schneider, Nicolas Ricodeau)	27.04.2023 (1h), Fribourg, University of Fribourg
Forest pasts and futures - IDANE Wald+ Science-Policy Workshop (various speakers)	09.11.2023 (full day), Lausanne, University of Lausanne
Forum für Wissen: Aus Störungen und Extremereignissen im Wald lernen (various speakers)	14.11.2023 (full day), Birmensdorf, WSL
Wald im Klimawandel (Esther Frei)	29.01.2024 (1h), Bern, Berner Botanische Gesellschaft
Eichen gegen Kiefern – wer gewinnt? (Stefan Eggenberg)	12.02.2024 (1h), Bern, Berner Botanische Gesellschaft
Vernissage: Arboreal Futures (art exhibition)	13.11.2024 (2h), Lausanne, Climanosco
Forum für Wissen: Extremes (various speakers)	03.04.2025 (full day), Birmensdorf, WSL
Forstwissenschaftliche Tagung 2025 (various speakers)	30.09.-02.10.2025 (full day), Freiburg i.Br., University of Freiburg/Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg

List of figures

Voluntary activities

May 2019 - April 2021	Vice President of the *Swiss Association of Student Organizations for Sustainability (VSN-FDD-FSS)*
April 2016 - May 2020	Board member (incl. co-president) of the association *NEUF (Sustainable Development University of Fribourg)*
Oct. 2016 - Sep. 2018	Board member (incl. treasurer) of the student body *Historia et Arte*; member of the student council of the organization *AGEF*

Skills

Languages:	German (mother tongue) French (business fluent) English (business fluent) Spanish (basic knowledge) Italian (basic knowledge)
Office:	Word, Excel, PowerPoint, Outlook, GIS, Alma
Knowledge of species:	Field botany skills (certificate 600 "Dryas" of *InfoFlora*) Ecological habitat knowledge according to *TypoCH* (course *InfoFlora*) Basic training for identifying butterflies according to *BDM Switzerland*

Publications

- Price, L., Vavvos, A., & Zumoberhaus, J. (2025). Call for papers: special issue on critical realism and human-nature relations. *Journal of Critical Realism*, 24, 504–507.
- Zumoberhaus, J. (2024). *Wald und Klimawandel – Zwischenergebnisse aus einer regionalen Fallstudie* (non-published summary of my work for field participants)

Teaching

- *Recherche empirique en sciences sociales III : Analyse et interprétation / Empirische Sozialforschung III: Analyse und Interpretation* (BSc, 2 ECTS)
  Autumn semesters 2021/2022/2023/2024/2025, weekly seminar of two lessons, bilingual French-German, in AS21 co-teaching with Romain Valadaud
- *Géographie urbaine à Fribourg / Stadtgeographie in Freiburg* (BSc, 0.5 ECTS)
  Autumn semesters 2021/2022/2023/2024/2025, one-day excursion, bilingual French-German, in AS21 co-teaching with Romain Valadaud
- *Excursion au Seeland / Exkursion ins Seeland* (BSc, 1 ECTS)
  Spring semesters 2022/2024/2026, two-day excursion, bilingual French-German, co-teaching with Mathilde Fautras
- *Field course in human geography* (MSc, 5 ECTS)
  Autumn semester 2022, field course of ten days, English, co-teaching with Olivier Graefe
- (Co-)Supervision and evaluation of several bachelor's theses and one master's thesis