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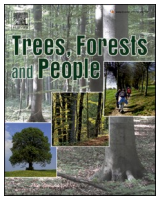

Forest science between human and nonhuman agency

Håkon Aspøy [a,b]

[a] Norwegian Institute for Nature Research, Oslo, Norway
[b] Department of Sociology and Human Geography, University of Oslo, Oslo, Norway

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ABSTRACT

This paper explores the distribution of agency in forest science. Studies of forest science tend to view it primarily as seeking to control and exploit natural resources. But recent turns in social theory open for understandings of human-nature relations beyond human control. This paper explores what such insights can mean for the understanding of forest science. It asks how nonhumans and nonhumans interact in practices of forest science and together constitute certain forms of agency. How are the activities engaged in by students and lecturers affected by nonhumans? How do they respond to nonhumans? The empirical scope of this paper focuses interaction between students and lecturers at bachelor's level. Fieldwork was carried out in June 2023 by joining students and lecturers on excursions. In-depth interviews with eleven students were also conducted. The paper observes how students and lecturers actively distanced themselves from the forest science of the past for ignoring the requirements of trees and the services of their surrounding environments. Indeed, lecturers repeatedly addressed preferences and performances of nonhuman beings. This had major implications for which decisions were available. The paper therefore suggests that nonhumans and humans interacted in numerous ways. Students and lecturers responded to trees, wildlife, soil, and climate. Nonhumans especially affected decisions related to logging and planting, thereby providing inescapable premises for the actions of forest science practitioners, and ultimately contributing to both enable and constrain agency. To conclude, the paper discusses a few limitations and implications of its findings.

Introduction

Norway's current forestry regime is controversial. Widespread practices include clearcutting, planting, soil scarification, and fertilization. Although such practices generally are accepted to impose great changes on forest landscapes, the extent and longevity of their environmental effects are disputed. Since the raised public awareness of global biodiversity loss from the 1990s and onwards, one contentious topic has concerned the implications of forestry for habitats and species (Aspøy and Stokland, 2022). Forestry companies tend to argue that the conditions for biodiversity are improving, but ecologists typically contend that this is only marginal compared to natural forests (Sverdrup-Thygeson, 2016). Another issue relates to forestry and climate change. Whereas forestry companies urge us to "think wood" (www.tenktre.no) for forest resources to replace fossil resources and thus mitigate climate change (e.g., Myhrvold, 2018), environmental organizations advocate increased conservation to maintain carbon stocks (e.g., Håpnes, 2018).

As forest science is confronted by environmental changes, there is a growing need for empirically grounded accounts of its responses. This article attempts to mitigate such a need. It explores how concerns related to climate and biodiversity are treated in forestry education and which implications they have for the education of future foresters. To do this, the article takes the Forest science program at the *Norwegian University of Life Sciences* (NMBU) as its case, which holds an unparalleled position in graduating practitioners for the various professions associated with forestry in Norway. By employing a relational and posthuman perspective on agency, the article asks whether and how humans and nonhumans interact and together privilege of some types of agencies in forest science over others. First, however, it gives a brief outline of the history of forest science.

Forest science

The history of scientific forestry is inextricably linked with Germany. More specifically, scientific forestry is commonly recognized as having emerged in Saxony and Prussia during the 18th century. According to Lowood (1990), forest management was one branch of the then new

E-mail address: hakon.aspoy@nina.no.

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construction of *Kameral-* or *Staatswissenschaften*. First offered by Prussian universities, the goal was to rationalize public administration with the objective of boosting state income. Key methodological means were quantification and standardization. For the sake of forests, this implied imposing a rational order on chaotic and unruly old-growth forests. Harrison (1992: 122) describes how forest science, *Forstwissenschaft*, a sub-discipline of the Kameral- or Staatswissenschaften, was conceived by an unprecedented application of mathematical methods in forest management. Indeed, to maximize growth and the production of timber, in the second half of the 18th century, German foresters increasingly turned to algebra and geometry. Thus, they were able to calculate timber mass, estimate growth, and determine ideal moments for felling.

Importantly, as noted by Lowood (1990: 319), the focus for forest managers until this period had not been timber production, but rather wildlife issues and hunting rights. But dwindling access to and surge in demand of timber in Germany, as well as elsewhere on the European continent, in the 18th century caught the attention of foresters and economists influenced by enlightenment ideas (Lowood, 1990: 318). With the implementation of forest science, forest management took a giant leap towards professionalization. Watkins (2014: 210) asserts that thanks to forest science and the professionalization of forestry, the forester by the middle of the 19th century was one of the most respected professions in Germany. According to Scott (1998: 19), the German model for forest science achieved a hegemonic global position by the end of the 19th century. This was also the case in Norway. In fact, the first Norwegians trained in forest science were sent to Germany commissioned by the state, by the time ideas of scientific forestry caught on in Norway, from the 1850s and onwards (Bækkelund, 2020: 41). A formal education in forest science was first available in Norway with the establishment of the *Norwegian College of Agriculture* ("Norges Landbrugshøiskole"), the precursor to NMBU, in 1897 (Bækkelund, 2020: 151).

Scott (1998: 15) describes how the methodological principles of the mathematically oriented forest science; rationality and order, after transforming conceptual understandings of forests transformed the materiality of forests themselves. The well-managed forest, meaning tidy, homogenous, and monocultural landscapes, geometrically planted with even aged trees, became the ideal image according to which forests were to be tended (Lowood, 1990: 341). Thus, the old-growth forests of Europe gradually were turned into even-aged monocultural landscapes (Harrison, 1992: 122). Harrison (1992: 107–108) shows that Descartes' view on mathematics, in particular algebra and geometry, as the means for humanity to become "the masters and possessors of nature" (Descartes, 2006: 51) entailed a turn from pre-enlightenment ideas of forests as sanctuaries which defined the limits of human exploitation to domains of utility.

Descartes' influential divide between humans and nature is related to his philosophy of knowledge. An essential component of this philosophy is a strict distinction between the subject of knowledge and the object of analysis; the subject as human knowledge and the object as nature (Harrison, 1992: 118). But the influence of the Cartiesian dualisms of human-nature and subject-object are not restricted to the natural sciences. By defining humans in opposition to nature, the humanities and social sciences were effectively separated from the natural sciences. In fact, as is widely recognized, this divide represents a defining aspect of the cultural heritage of the social science, sociology in particular (Macnaghten and Urry, 1995; Redclift and Woodgate, 2013; Rice, 2013; Ross, 2017).[1] However, recent theoretical advancements in social theory attempt to break with the Cartesian dualisms underpinning modern science.

[1] Although, as Karakayali (2015) shows, the history of sociology also includes attempts at locating a common ontological ground for both nature and culture in the early days of the discipline.

Agency beyond humans

Indeed, in several strands of contemporary social theory, scholars are exploring questions beyond Cartesian dualisms. A common argument is that because dualisms reduce complexity, rethinking dualisms opens for studying complexity that previously have been overlooked (e.g., Höppner, 2017). This development has resulted in a rich literature accompanied by a vocabulary for describing phenomena which escape the distinctions and categories of modern science. Examples include "boundary objects" (Scoles, 2018), "messy" realities (Law, 2004), "hybrids" (Latour, 1993), "cyborgs" (Haraway, 2000), "sticky" markets (Schöps et al., 2022), and "slippery" salmon (Law and Lien, 2013).

This article focuses on the assumed distinction between humans and nature. A crucial conceptual question concerns the concept of agency. The background is the Cartesian idea of nature as an arena for human exploitation, which ascribes agency solely to the human realm. According to Latour (1993: 138); "modern humanists are reductionist because they seek to attribute action to a small number of powers, leaving the rest of the world with nothing but simple mute forces". The implication is that in modern culture, agency beyond human definitions has been overlooked. For scholars challenging the human-nature dualism, often referred to as *Posthumanists* (Kipnis, 2015), an important rationale is to understand how agency is enabled. Agency here is regarded as an attribute of connections. It is not the property of single entities, such as an individual, an organization, or a social class. Rather, agency is made possible by networks. Furthermore, networks are made up of both humans and nonhumans (Latour, 2005). Commenting on Laidlaw's (2010) discussion of the different approaches to agency in practice theory and actor-network theory, Kipnis (2015: 50) notes that:

> Practice theory led to a conception of "agency" as an abstract capacity held by particular individuals and opposed to the social "structures" that restrain those individuals. (…) But such a concept of agency cannot explain how people become agents of a particular type. It ignores the necessity of agency arising through entanglements.

Entanglements refer to the relations by which how agency is made possible. Jones and Cloke (2002: 68) emphasize the "need to recognize the mutual constitutive role of humans and others". In such a perspective, agency is constituted by both humans and nonhumans. In their study of tree cultures, they advocate empirical accounts that are sensitive to heterogenous sets of actors:

> In contemporary understandings of nature-society relations it is recognized that nature is not merely inscribed upon by human culture and practice. Rather, nature 'pushes back' with its own vitality which is manifest in specific material processes (Jones and Cloke, 2002: 6).

A key motivation of dissolving the human-nature dualism is that this can help to unveil phenomena created by humans and nonhumans together. By moving past narratives of human control, we can develop a deeper sense of how nature is not only acted upon, but also performs agency.

But what is meant by agency? Several notable contributions have been made to decouple agency from human attributes such as intentionality and subjectivity. Instead, alternative criteria for agency are proposed. Latour (2005: 71) asserts that when considering whether someone or something is an agent, we should ask:

> Does it make a difference in the course of some other agent's action or not? Is there some trial that allows someone to detect this difference? The rather common sense answer should be a resounding 'yes'.

According to Latour, we should ask if one agent *affects* other agents. Further, agency arises by virtue of connections. Latour (1984) refers to the "powers of association", suggesting that power or the capacity to act depends on a variety of people, meanings, and artifacts. Indeed,

actor-networks consist of both human and nonhuman *actants*, which together make agency possible. Latour (2003) dismisses the notion of *social* constructivism and argues that to understand agency one must also consider material realities. In a relational perspective, agency arises as different actants, such as people, things, and natures, come together. For our purposes here, this pertains to the situations in which human practitioners of forest science encounter the many nonhuman beings of forests. In other words, this paper is interested in how the coming together of different entities makes some actions possible and others not. Sayes (2014: 141) suggests that with this line of theorizing, agency is dehumanized, and that rather than being restrained by human traits such as language and intentionality, the threshold for agency is reduced to "the ability to make a difference".

Scholars advocating posthuman perspectives have argued that opening for accounts of nonhuman agency is a fruitful point of departure for more socially just research (e.g., Brown et al., 2019; Healey and Pepper, 2021). Indeed, it has been asserted that this is a way forward for realizing more of the emancipatory potential of empirical studies (Taylor and Sutton, 2018). More recently, this has been referred to as "an ontology for the Anthropocene" (Benson, 2019). In fact, as multiple current environmental crises boldly contradict the alleged distinctions between humans and nonhumans, novel ways of theorizing about the interconnections between humans and nonhumans leave researchers better conceptually equipped for empirical studies of power in the Anthropocene (Tønder, 2020).

Posthuman perspectives have been used to study many different phenomena. These include technology (e.g., Woolgar, 1990), bioscience (Lee and Helgesson, 2020), markets (Schöps et al., 2022), animals (McPhail and Ward, 1988), and plants (Elton, 2023). According to Jones and Cloke (2002: 48), there has been an over-emphasis on the nonhuman agency of technological artefacts and an under-emphasis on organic entities, and, in the latter category an abundance of human-animal studies (ibid: 53). Since the time of their writing, this development has largely continued. Empirical accounts of human-animal relations have even given way to numerous different subfields, including *anthrozoology* (Irvine, 2004, 2012; York and Mancus, 2013), *animal geographies* (Morin, 2015), *animal sociology* (Taylor and Sutton, 2018), and *critical animal studies* (Taylor and Twine, 2014; Nocella et al., 2014). Since Jones and Cloke's own account of the agency of trees (2002) a greater diversity of nonhuman agency has been included in empirical studies. Posthuman literature now entail accounts of the interplay between a wide range of different forms of nonhuman agency and human agency. These include mushrooms (Tsing, 2011, Tsing, 2015), rivers and water (Strang, 2014), plants (Elton, 2023), forests (Kohn, 2013), and abiotic elements (Reinert, 2016; TallBear, 2017).

By asking how nonhumans and humans come together in forest science, we can proceed past exclusive accounts of human agency. As highlighted by its history, forest science in many respects represents a desire to control and exploit forests. However, studies which solely focus on humans cannot be the starting point of a sociology of forests that is aware of the changes in the Anthropocene. By exploring the implications of nonhumans for agency in forest science, we can perhaps move towards a more comprehensive understanding of forest science and the tensions by which it is currently confronted.

Methodological approach

Studying nonhumans

Studying nonhumans is not straightforward. Indeed, it introduces several complications, depending on the species or entities in question. A troubling aspect of forests regards their temporalities. Trees grow slowly and visible changes may take years or even decades. Ethnography, therefore, hardly allow for observing trees in the same ways as humans. Rather, this article focuses on how both nonhumans and nonhumans affect practices of forest science. Such an approach could be argued to give priority to human knowledge. But as Tsing (2013: 34) notes: "We'll never have the chance to become plants". She proposes to take human knowledge as a starting point. In her view, this is opens for studying "the forest's web of social relations" (Tsing, 2013: 36). In other words, human knowledge can indeed be a fruitful outset for studies of entanglements of humans and nonhumans.

This does not imply that sentience, or knowledge of the peculiarities of nonhumans, is necessary for studying agency. Instead, agency occurs as humans and nonhumans come together. Producing knowledge, such as in the case of forest science, is one among several ways humans and nonhumans may interact. This view resonates with that of Sayes (2014: 141), who argues that studying nonhuman agency through human activities does not equal a human-centered notion of agency. This further echoes the relational perspective of many posthuman studies. Again, agency here arises by virtue of entanglements or networks. This article adopts a similar approach. It takes an allegedly human practice as its starting point for asking how nonhumans make a difference, how they affect other actants such as humans, and how they contribute to agency.

Choice of case

Forest science at MINA, NMBU, was chosen as a case due to its unique position in a Norwegian context. As a leading educational institution in its field, MINA is responsible for educating and graduating an unmatched number of foresters. The empirical scope of this paper is limited to Forest science on bachelor's level. Whereas both the university and the faculty in their current states are relatively recent constructions, their history with forest science dates to 1891. Then called the *Norwegian College of Agriculture*, it was the first Norwegian institution to offer higher education in forest science, providing graduates with the title of *Forstkandidat*, a term borrowed from Germany (Bækkelund, 2020). To study forest science education, MINA and NMBU represent an unmatched case.

Fieldwork and interviews

Fieldwork was carried out in May and June 2023. Initially, the article focused on how forests were approached in two different bachelor programs. In addition to Forest science, fieldwork was done at Ecology and natural resource management, also at MINA, NMBU. Four days of fieldwork was completed for each program. An early research interest focused on how forests were addressed in similar or different ways. However, when assessing the data, a decision was made to write one paper for each study program instead. The reason for this was twofold. First, despite the limited span of the fieldwork, amounting to eight days combined, data became richer than expected. Second, the alleged tensions between the two study programs were less analytically interesting than assumed.

The course in forest science ran in the spring semester of 2023. One lecturer described it as a fusion of the entire bachelor's degree, combining lessons from multiple previous courses. It was also described as practice-based, in that students were given the opportunity to carry out what they had learned in practice. The course was followed as students practiced fieldwork on a specific forest property. Of the four days, two were devoted to excursions and two were devoted to analyzing the data gathered during the excursions. To result from this was the deliverable of the course: a forest management plan. Written for the forest owners, the plan consisted of a range of recommendations for how to tend different parts of the forest property. In addition to fieldwork, six qualitative interviews were conducted: two focus groups and four individual. In total, eleven students were interviewed. The interviews were semi-structured, partially assisted by an interview guide. Often, the conversations floated freely. Most topics from the interview guide were covered, nevertheless. Interviews were carried out when the students had the opportunity, often in between tasks or during breaks. The groups

were organized spontaneously but partly overlapped with the working groups already established by the course organizers. For the first focus group interview, a student from one group joined the interview with another group. For the second, an entire group participated.

Coding and analysis

Field notes were written by hand while following students and lecturers in the field. The initial notes were short and concise. They provided the basis for a more exhaustive computer-written account. Because the educational program lasted more than 12 h, there was little time left to write more elaborate field notes by the end of each day. These were therefore completed after the fieldwork had been completed.

The recordings from the interviews were transcribed in late June and early July 2023 by using the software f4Transkript. In conducting the analysis, data and theory were considered alternately, similar to the logic of stepwise-deductive induction. Tjora (2018) describes this process as an effective way of moving from raw data to analysis, all the while paying close attention to both data and theory, actively working to achieve grounded analyses. The procedure entails moving back and forth between data and theory in the analytical process.

Other potential themes were explored underway, especially the construction of boundaries towards other disciplines studying forests. However, from analyzing the data boundary making emerged as a less fruitful approach. In contrast, the concept of agency beyond humans applied to many parts of the data, hence providing the basis for a rich analysis.

All quotes from field notes and interviews have been anonymized out of concerns for the informants. Quotes have also been translated from Norwegian to English by the author.

Considering deciduous trees

The forest property we visited was privately owned, but at the disposal of students and lecturers for educational purposes. In advance, the students had been introduced to the forest owners by the course organizers and provided with key information regarding the property. One vital piece of information concerned tree species. The forest owners wished to focus specifically on cultivating spruce for timber production. However, spruce was not the only tree species growing on the property. In fact, students and lecturers encountered multiple tree species. Knowing the forest owners' preferences for spruce, the students faced questions related to how to address other tree species, deciduous trees in particular. This sparked conversations in which a variety of performances of birch and other deciduous trees were recognized. These performances had implications for how students and lecturers reasoned concerning appropriate decisions for future management.

Birch as competitor

Among the deciduous tree species on the property, birch was observed in several of the groups' designated areas, referred to as *stands*. Birch, then, became a recurring topic of discussion. Considering the focus on growing spruce, what piece of advice should the students give concerning birch? Faced with this question, Thomas, a professor in forest science, on one occasion assessed the birch trees in question from a distance and answered:

> In principle they should be cut down to liberate the spruce. Always keep the spruce in mind. (…) Often, the birch will become a competitor to the spruce.

Here, spruce is clearly given priority over birch. Indeed, a principal stance is taken to sacrifice birch trees to the benefit of spruce trees. Interviewing Christopher, one of the students, the relationship between spruce and birch became a topic again:

> I think that in young forests, we should remove birch more or less entirely (…) to assist the tree species we wish.

Asked about whether birch competed with spruce, he said:

> Yes, it does. (…) Actually, we refer to birch as the rock star of the forest. It's the fastest growing tree species. (…) We risk, in young forests (…), that the birch surpasses the spruce. The spruce is not that tolerant of shade (…) If the birch surpasses the spruce, it takes up more water, it puts the spruce in the shadow and makes sure that the spruce grows slower. The birch takes up more nutrition from the ground.

In the conversations with Thomas and Christopher, birch acts as a *competitor*. Its behavior entails a threat to the growth of spruce. It requires attention and action, primarily by removal. The inclination of birch to act as a competitor to spruce thus had implications for which decisions were available. This aspect of birch affected the discussions in that it limited the range of possible decisions, of course, in the context of producing spruce.

Birch as opportunity

However, birch not only showed itself as negative. In fact, birch performed several tasks which were appreciated. One of these was related to financial income. To a group of students, Thomas emphasized that not all birch would have to be cut down for the sake of spruce:

> But where birch can be left to grow, it can be used for firewood, as the forest owner already produces that. You should always think about that you should make as much money as possible. With today's high prices for firewood, birch is potentially very valuable.

Where it did not interfere with spruce, birch provided opportunities. It offered the possibility of financial gain, considering the forest owner's existing production and the relatively high market value of firewood. In that sense, the foresters' assessments responded to both the forest owners' agenda, the market's value of firewood, and at last, the ability of birch to act as firewood. The prosperity offered by birch provided a reason to leave birch for the time being, thus affecting the range of decisions available again.

Birch and other deciduous trees as biodiversity

Discussions of logging operations revealed another positive function of birch. Here, the implications of birch for other species were enhanced. For instance, asked by one of the student groups about how to treat birch trees in their stand, Thomas said:

> Some of these can be appropriate to spare as retention trees.[2] Find some that are rich in biodiversity when you identify such trees.

Retention tree is a term used for a tree that is left to grow after clearcutting due to assumed important functions for the ecological environment (Gustafsson et al., 2010). Inger, another professor in forest science, also emphasized the need for deciduous trees even though commercially they were of secondary interest at best, hence alluding to their ecological functions:

> You should facilitate a significant share of deciduous trees. Also, deciduous trees should be given priority when leaving retention trees.

She later elaborated on why one should prioritize deciduous trees for such purposes. On one occasion, we were following a group as it became acquainted with its designated stand. A gap in the ground ran through

[2] "Retention tree" is translated from "livsløpstre" (https://static02.nmbu.no/mina/div/skogordbok.php).

the stand. The students were discussing that if it was a stream, they would be required to refrain from logging the trees along it, hence leaving a buffer zone. Inger concluded that it was a ditch and thereby "not natural". But she advised the students to leave some of the trees anyway:

> The big birch trees I think you should leave standing. They keep the ground in place.

She then became aware of a rowan, another species of deciduous trees, standing alongside the ditch, and said:

> You should also advise the forest owner to leave the rowan. We want rowan. It's an important tree and there's very little left of it in Norwegian forests. It's a good grazing tree. Moose love it. That's why they've become so rare.

In my interview with Christopher, he too spoke about the relationship between deciduous trees and other forest-living species. Asked if birch had any benefits, he answered:

> As I said, birch drains well. It takes up a lot of water. So, where it's very damp, we need birch. If not, it will become a swamp. And in addition to that, birch is a habitat for other species than spruce, for instance.

Apart from trees, Christopher was interested in wildlife, being an avid hunter in his spare time. To him it was important that forests provided food for wild animals:

> Both rowan, aspen, and willow are important species to take care of in the forest. They provide food for the moose. And then we can also prohibit it from attacking the pine. So, I think we need to find a balance between the species we wish to keep, but also species needed by the rest of the environment and species to manage.

Here, deciduous trees performed a third function, namely to secure *biodiversity*. This included not only providing and habitats for other species, but also offering their services to its surrounding environment more generally. The capacity of deciduous to act as substrate for other species affected the range of available decisions again, this time calling for care.

The agency of trees and wildlife

Above we see that birch performs three different functions. First, birch competes with spruce. Second, birch provides financial income (as firewood). And third, birch (and other deciduous trees) offers food for and other services to other species and its surrounding environment. What gives coniferous trees significance is the ways in which their abilities stand out. By standing out, they stand apart from coniferous trees. The priority of the forest owners to produce timber from spruce means that the complimentary abilities of deciduous trees and their services vis-à-vis coniferous trees are important. Interaction between coniferous and deciduous trees did not go in the other direction. In other words, the abilities of coniferous trees are not apparent from how they interact with deciduous trees. Thus, if coniferous trees, and particularly spruce, represents a center, then deciduous trees which revolved around that center. So let us take a closer look at the role of coniferous trees.

Considering coniferous trees

Deciduous trees were largely defined by how they were different from coniferous trees. Indeed, as noted, the lecturers stressed the students that spruce was *the* focus of the forest owner. This had implications for the students' production of knowledge. Aside from making other tree species secondary, it also had consequences for which attributes of coniferous trees which affected the activities of students and lecturers.

"Spruce on pine ground"

A matter that was given great attention was the relationship between different tree species and their growing conditions. But in contrast to birch, which in several respects was defined by the services of the trees to their environment, with spruce it was the other way around. Indeed, here the services of the environment to spruce were in focus. However, this did not mean that little attention was given to the abilities of spruce. On the contrary, the requirements of spruce for optimal growth were frequently addressed. One defining condition for spruce was that of the ground in which it grew.

This was a hot topic on the third day I followed the students and lecturers, when the topic was logging. Inger, who gave an introductory lecture, said that the overarching goal for the students was to "evaluate future development possibilities" for their designated stands. All five groups had received one area each that based on age of the trees was assumed to be relevant for logging. As part of this the groups would make four different assessments, Inger explained. They were to discuss logging methods, tree species shift, natural regeneration, and other silvicultural measures. This meant that the students were tasked with making assessments related not only to logging itself, but also how their stand should be managed in the future. Indeed, the students were urged to critically consider whether the tree species growing in their stands were appropriate and ought to be planted anew after logging. The procedure for the students to do so was referred to as a *site description*.[3] According to Inger, such descriptions were not yet very established in Norway but would have to be:

> We need to think about what [tree species] will stand there in the next generation.

Arriving in the field, visiting professor Finn was ready to provide a more detailed description as well as demonstrating its procedure. Well inside a forest area populated by spruce, he spoke up and said:

> What should be take into consideration? We should especially ask which tree species are suited for the area. We must examine the ground, vegetation, meters above sea level, climate, and topography.

Particular attention was paid to the ground. Finn brought out a kind of drill ("jordbor") that was shaped like a T. He then demonstrated how to use it by inserting it firmly into the ground beneath him and rotating it, making a drilling-like movement. After around 10 cm, we could hear the drill hitting something hard. Finn looked at us with an ironic smile:

> No, we've hit stone.

He pulled the drill up from the ground. The bottom part of the drill was hollow on the inside so that it captured a sample of the soil's composition. Finn looked at it and proclaimed that the soil consisted of:

> A thin layer of hummus and fine-grained earth. (…) The soil is brown, thus not water saturated,[4] and shows several signs of oxidation.

Finn went on to explain that he could have hit a single stone that was not representative of the depth of the soil. But, he said, the dead spruce trees on the edge of the area were signs that something was wrong, hence alluding to the soil possibly being too shallow for the spruce that had been planted there. In a tone indicating that the answer was no, he asked the students:

> Can we recommend planting spruce here?

The relationship between tree species and their growing

[3] "Site description" is translated from the Norwegian term "voksestedsbeskrivelse". "Voksested" is translated to "site" in NMBU's silvicultural word list (https://static02.nmbu.no/mina/div/skogordbok.php).

[4] Translated from "vannmettet" – a measure for soil moisture.

environment also became a topic when I interviewed Christopher. As with all students, I inquired about which species he took a liking to. But rather than merely responding, he changed the premises for my question:

> Well, I think it's a matter of the right tree species in the right place, really.

I told him that I had heard that spruce was planted in many places where it did not thrive. Christopher shared such a view:

> Yes, there is spruce on pine ground a lot of places, in big parts of Norway.

When I asked him how one should approach this issue, he responded:

> It's like Finn mentioned yesterday when we started out. We need to focus more on finding out which tree species that should be in the different types of soil. And assess that in relation to logging. And ask critical questions: whether it's right that there should really be spruce here. Or should there be pine?

The expression "spruce on pine ground" meant that the soil had implications for which tree species could be planted there. This largely derived from several conditions of the ground, such as depth and moisture, and the tree species' requirements for growth. Certain types of soil did not allow spruce to thrive. The expression also implied a criticism of an exaggerated focus on spruce and an ignorance of its needs and how these interact with the conditions of the soil. The planting of spruce on "pine ground" was an unwarranted practice that had to be reversed. This acknowledgement imposed a limitation regardless of the forest owners' preferences for spruce.

Climate change

Another key consideration of a site description was the local climate. Or, put more specifically, a site's *new* climate. Indeed, students and lecturers frequently noted that the climate was changing. Climate change imposed yet another restriction on forest science, one that had taken them by surprise and invalidated many decisions of the forest science of the past. Little time passed without climate change being brought up. On the first day, on the way to the field, I drove together with Thomas. When he raised the subject of the effect of climate change on Norwegian forests, I asked him what the effects were so far. Thomas pointed to the right and said: "Just look over there". He pointed to a forest area of several grey, dead-looking spruce trees. Then he said:

> Spruce is particularly prone to drought because of its short roots. In contrast to pine, which has long roots, spruce roots are like a lamp base. Therefore, it's also more exposed to windthrow. I think it's very alarming. In Norway, we've planted so much spruce. But it deals really badly with drought. I've almost never seen a dried-out pine tree.

Daniel, Thomas' co-lecturer, was worried about this year's conditions:

> There's been little rain lately. Will we have another year of drought?

In the weeks and months leading up to our excursion, there were many dry and sunny days. There were a few showers of rain earlier in the morning of the day of our first excursion and the day before. But Daniel said that it was so little that he felt sure the ground inside the forest was already completely dry by the beginning of the excursion. As they walked from group to group to assist the students, Thomas and Daniel inspected the ground here and there, using their bare hands. In one of the locations, Thomas was surprised by the degree of humidity:

> It's actually pretty damp downwards!

Drought was also emphasized as a crucial topic by Finn. The area where he demonstrated the drill contained several recently dead spruce trees. Finn said they most likely died from the drought in 2018. To know which tree species were appropriate on a given location, Finn said:

> We must try to get a picture of how deep the soil is. In drought conditions, the trees need deeper soils. (…) When considering tree species, we must link climate conditions with soil conditions.

Inger, too, raised issues related to climate change. In her lecture on thinning, meaning the removal of some trees to concentrate the growth to others, she asserted that climate change made thinning more important:

> Why do thinning? The main idea is to concentrate the growth to the best trees. Thinning also has a new function because of climate change. More drought means more competition for water between the trees. This is even more critical for spruce which is planted in places it isn't suited. Thinning can help to buffer this problem. By thinning, we choose which trees win the competition.

She also mentioned climate change as one of the reasons why site descriptions would have to become more widespread in Norway. In addition to getting an overview of the depth of the soil, taking species into account was also part of the site description:

> We're also going to identify species. Are bog billberries becoming established while blueberries are disappearing? If so, it's starting to become too dry for spruce.

The climate was recognized as something beyond control. But it was not a stable and predictable backdrop to forest science. It acted surprisingly, changing the premises for forestry to be successful. This had unprecedented consequences for forest science and affected its practices in several ways, specifically with the implementation of a range of new assessments associated with the site description, but also more generally by limiting the applicability of spruce.

The agency of soil and climate

Carrying out site descriptions represented a radical break with earlier forest science practices. By denouncing what was considered an exaggerated and in many instances inappropriate focus on spruce, more factors were included to consider the suitability of different tree species. Climate and soil were crucial elements for planting spruce. In the relationship between spruce and climate and soil, the interaction went mostly in one direction, by the influence of climate and soil on spruce and to a lesser degree the other way around. But as we have seen, the behavior of spruce was emphasized, too. Its requirements for water, climate, and soil conditions limited its applicability and therefore restricted the opportunities and flexibility of the human agency of forest science. The assessments related to tree species, soil and climate entailed a re-orientation of forest science, more adjusted to the requirements of spruce and the conditions offered by climate and soil. Climate and soil thus affected the considerations and recommendations of the students and lecturers in several ways.

Concluding notes

This article gives neither a full-fledged nor a representative account of how forest science engages with nonhumans. It does, however, provide some insight into ways in which humans and nonhumans interplay and affect which actions are possible and which ones are not, hence together constituting agency. More specifically, it offers an empirical case of how forest science is confronted with surprising, unruly, and changing nonhuman entities of forests. A take-away point from this is that although forest science is part of a Cartesian legacy, its practitioners interact with nonhumans in many respects. Several of these were related to the ongoing environmental changes which occur on a global scale, such as climate change and biodiversity loss. Moreover, they imposed severe challenges on forest science. The interaction between nonhumans

and humans in forest science together resulted in a specific set of configurations and reconfigurations.

It is important to recognize, though, that this is merely a snapshot. The picture that emerges from this study is not static. Many scholars working with concepts related to agency beyond humans have also embraced the view that realities are not given but constantly performed (Law, 1999; Mol, 1999). Nevertheless, the discussions of forest science observed here address largely the same overarching concerns as the forestry related discussions in a broader Norwegian public discourse. Whereas such discussions long have been restricted to the effects of forestry for biodiversity, recently there has been an increased focus on alternative forestry practices. One is related to moving beyond even-aged forestry (e.g., Andersen, 2021). This paper provides an image of how such questions are addressed within forest related learning communities.

Changes in public discourse along with the criticisms of its practices of the past justifies asking whether the engaging with nonhuman agency in forest science is a new phenomenon or not. Scott (1998: 21) argues that forest science early became aware of its negative effects and took measures to restore some of the ecological functions which were severely reduced by modern forestry. This did not mean bringing back diversity per se, but rather mimicking some aspects of old-growth forests in monoculturally planted forest landscapes. While this in some respects resembles the findings of this paper, again, the discussions observed here are closely attuned to current environmental discourses, especially associated with climate change and biodiversity.

Forest science represents one of several scientific approaches to forest management. The ways in which nonhuman agency mingle with human agency in other disciplines remains an open question. Indeed, forests are studied and managed on multiple scales and levels, by people and institutions, from the public sector to private enterprises, learning communities, and scientific institutions. More research is therefore required for more comprehensive understanding of the interaction between multiple actants and the agencies they comprise. Thus, can we move towards to a sociology of forests that does not assume human exceptionalism but is conceptually rigged for understanding a multitude of dynamic human-nonhuman relationships.

CRediT authorship contribution statement

Håkon Aspøy: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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