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Article

Intensive Forestry as Progress or Decay? An Analysis of the Debate about Forest Fertilization in Sweden, 1960–2010

Anna Lindkvist [1,*], Örjan Kardell [1] and Christer Nordlund [1,2]

[1] Department of Historical, Philosophical and Religious Studies, Umeå University, 90187 Umeå, Sweden; E-Mail: orjan.kardell@idehist.umu.se

[2] Torgny Segerstedt Pro Futura Scientia Fellow, Swedish Collegium for Advanced Study (SCAS); Max Planck Institute for the History of Science, Boltzmannstraße 22, 14195 Berlin, Germany; E-Mail: christer.nordlund@idehist.umu.se

* Author to whom correspondence should be addressed; E-Mail: anna.lindkvist@historia.umu.se; Tel.: +46-90-786-5413; Fax: +46-90-786-7667.

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Abstract: In the mid-1960s, fertilization (with nitrogen) had a breakthrough as a promising forest management method in Swedish company owned forests. The activity grew and peaked during the 1970s but then lost ground and stabilized at a low level in the 1990s and early 2000s. Over the last five years, however, interest in fertilizing Swedish forests has increased again. In this article both the forestry industry's, and the environmental movement's, attitudes toward forest fertilization over time are investigated. Furthermore, conflicting persistent ideas about nature and future, *i.e.*, "figures of thought", within interest groups, representing forestry and the environmental movement respectively, are identified and analyzed in relation to the debate on fertilization. The analysis reveals mainly three figures of thought that have influenced this debate during the period, "the idea of progress", "the idea of decay" and "the idea of the great chain of being". The study thus sheds light on how the relationship between forestry and the environmental movement has evolved from the 1960s until today and uncovers thought patterns that have stood, and continue to stand, in opposition to one another.

Keywords: Swedish forestry; forest fertilization; environmental history; forest history; environmental debate; discourse analysis; figures of thought

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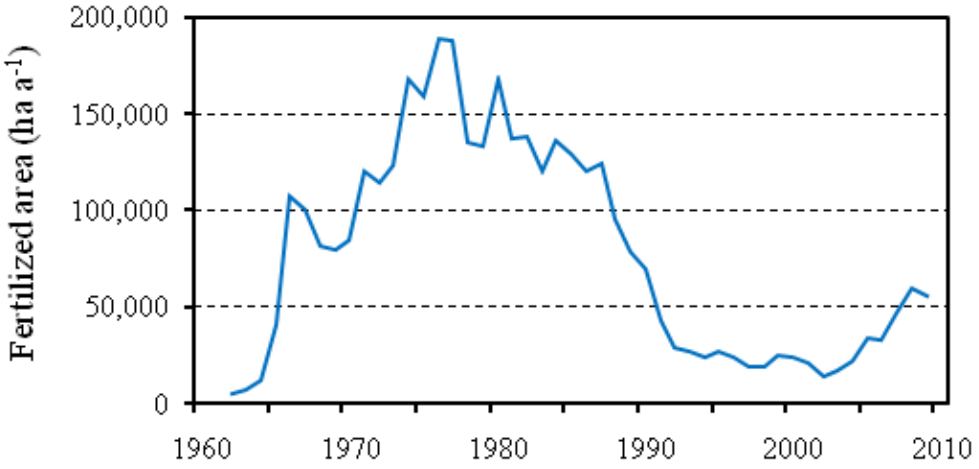
1. Introduction

Since the 1950s the fertilization of forested land using nitrogen has been promoted as one of the most effective and cost-effective methods of rapidly increasing tree increment, and thereby, forest owners' opportunities to increase timber harvest. Nitrogen fertilization first became widely used within Swedish company- and state-owned forests in the mid-1960s, reaching a peak of approximately 190,000 hectares a year in the mid 1970s (Figure 1). The popularity of the method later declined, stabilizing at a greatly reduced level during the 1990s and early on in the first decade of the new millennium.

Figure 1. Forest fertilization in Sweden, 1962–2009. Large-scale fertilization with nitrogen on mineral soils [1-6].



The total use of synthetic fertilizers in all sectors in Sweden increased from 80,000 tons per year in 1939/1940 to 414,000 tons in 1971/1972. During the same period, the annual use of nitrogen increased from 30,000 to 233,000 tons. Without doubt, agriculture has always been the largest consumer of synthetic fertilizers. In the beginning of the 1970s, statistics showed that agriculture consumed 12 times more nitrogen than forestry [7]. Forestry's use of fertilization has not been insignificant, however, and neither has it been viewed as unproblematic—in fact, quite the opposite. Fertilization has been the subject of a series of debates and conflicts, particularly during the 1970s and 1980s, when forest fertilization was most extensive and intensive forest management with high production targets was both prioritized and strictly regulated by the Swedish state.

Forest fertilization declined in the 1990s in line with the adoption of ideas about a "forestry with an ecological focus" [8]—ideas that had been proposed by environmental organizations and ecologists since the 1970s—in policies and by the forestry industry. One clear upshot of the increasing ecological focus was the revision of the Swedish Forestry Act (1979:429) in 1993/1994. The revised act, still named the Swedish Forestry Act (1979:429), established that environmental and production goals should be weighed equally in Swedish forestry. At the same time, the act was characterized by a substantial deregulation and much of the former severe governmental control of the high-output forestry was removed (e.g., [9,10]).

In recent years, however, interest in intensified forestry, including increased fertilization, has once again come to the fore in Sweden. This interest can be seen in the Swedish Forest Agency's statistics concerning silvicultural measures implemented [6] in a number of forest policy reports from recent years [11-13] and in campaigns by the Swedish forest owners' movement [14]. This about-face is linked to the desire within the political sphere to further promote the domestic production of both traditional wood goods and biofuels; the intention being that forests will thereby contribute to both increased economic growth and to the management of global warming, in line with the principles of "ecological modernization". However, this change in attitude also indicates a shift away from the view of the forest's resources and forestry activities as held during the 1990s.

Those of us who conduct research from the perspective of environmental history as part of the "Future Forests" program have been given cause to consider how greatly intensified forest fertilization would be received by the community in general and by the environmental movement in particular. Given the fact that forest fertilization on a large scale gave rise to conflicts between different interested parties previously, there is good reason to believe that such conflicts may arise again. We have chosen to approach this problem by tracing and analyzing attitudes and approaches that have been voiced in the debate about forest fertilization and intensified forestry over the years. Inspired by sociologist and theorist of science Johan Asplund, we have also attempted to relate these attitudes and approaches to specific persistent ideas about nature and the future, in what is referred to as "figures of thought" [15].

This article is thus a study of the history of ideas about forest fertilization and, as such, it is a contribution to the field of environmental history. Our intent has been to better understand both past and current divergent opinions in Sweden about forest fertilization, to facilitate reflexivity concerning the pros and cons of this technique, and, in the end, to give food for thought about the cultural conditions for intensive forestry in the near future.

2. Experimental Section

2.1. Objective

The purpose of this article is to investigate both the forestry industry's, and the environmental movement's, attitudes toward forest fertilization over time, as well as to uncover on a deeper level the different "figures of thought" that have manifested themselves in the debate between the two groups. The intention is to thereby expose the persistent thought patterns about nature and the future that have previously stood in opposition, and continue to stand opposed to one another. The study has been defined using the following questions: How did the interest in fertilizing forested land develop? Which fundamental arguments, both for and against forest fertilization, were expressed during the latter half of the 20th century? What relationship is there between today's arguments and earlier arguments? Which figures of thought form the basis of the arguments?

2.2. Theory

This is a historical study using methods borrowed from the history of science and ideas. This means that the relevant parties' and stakeholder's views of, and attitudes towards, forests and forest fertilization were the primary object of the study, as opposed to forests and forest fertilization

per se [16]. It also means striving to define differences of opinion in a symmetric and neutral way, so that different perspectives are brought to light.

On the theoretical level, the study has been inspired by Johan Asplund's heuristic model for idea-critical research. This model is based, in part, on the ideas of the Annales school on mentalities, such as ingrained thought structures, and on Michel Foucault's discourse theory, but it also draws on the Marxist theoretical framework of base and superstructure [15,17,18]. One of its central concepts is "figures of thought" [15].

A "figure of thought" is, briefly defined, a persistent idea which more or less implicitly influences the way people understand their surrounding world [15,19]. This definition might fit as well for some interpretations of the theoretical concept of "discourse" [20]. In Asplund's version, however, figures of thought and discourses have different properties. Discourses are shorter-lived and more volatile than figures of thought and any number of discourses may exist at any one time. Figures of thought, on the other hand, are persistent and fewer in number. Only a small number of figures of thought exist within a single age and culture. A figure of thought is resilient inasmuch as it is able to survive even rapid and violent changes in the base, *i.e.*, in the material conditions of a society, and remain primarily intact, or, at most, only partially altered. Figures of thought are, however, not assumed to be eternal. Although multiple figures of thought may be present in a society at the same time they may also cause conflicts between people who hold on to incompatible figures of thought [15].

Additionally, figures of thought are characterized by the fact that, as a rule, they are unspoken by those parties or groups that hold them. The complex of attitudes contained in the figure of thought first reveals itself as explicit ways of thinking at the discursive level, *i.e.*, in the arguments and values expressed in a debate [15].

Asplund posits that research into the history of ideas has so far revealed only a limited number of "real" figures of thought [15]. Some examples of these are the idea of progress; the idea of existence as a great series or chain of being; and the idea that the earth has a limited lifespan, that it is ageing, deteriorating, and approaching its own demise. Each of these main ideas is considered to have been especially influential, *i.e.*, to have dominated discourses in previous centuries. The idea of the ageing of the world—the idea of decay, or *mundus senescens*—was very prominent during the 1600s, while its antithesis, the optimistic idea of progress, dominated the 19th century. By way of contrast, the 18th century was characterized by the idea of the great chain of being, which according to Asplund found expression in Linnaeus' work on the classification and systematization of plant and animal species [15].

These real figures of thought have also played a role in the way people (at least those in the Western cultural sphere) have formulated conflicting expressions about nature and the future, and they remain with us to this day [15]. In this study, we will demonstrate how the real figures of thought influenced the debate about forest fertilization during the 1960s and 1970s. We will also examine and discuss the way they continue to color present-day debate concerning intensified forestry, including increased fertilization.

To give further guidelines to the reader we present definitions of these figures of thought as they will appear in this article. As we understand them, both from our own analysis and from previous research, the three real figures of thought, as presented by Asplund, or "transformations" [15] of them, have been constituted as follows during the last six decades: "The idea of progress" has represented faith in humanity's ability to increase and process the earth's resources. It thus implies that mankind

has supremacy over nature. It also implies that the future will always be brighter than the past as long as we develop new technology and foster economic growth. Previous research has strongly connected these ideas to the mid 20th century, especially to "the happy 1950s" (e.g., [21-24]).

In the 1960s, *i.e.*, the time for the awakening of the modern environmental movement, the idea of progress faced new competition from "the idea of decay". Previous research often assigns the modern breakthrough of this figure of thought to the Club of Rome and the presentation of their study *The Limits to Growth* in 1972. In contrast to the idea of progress, this figure of thought turns the spotlight on concerns about the earth's limited resources and the survival of the planet. It implies that humankind should adapt to nature's resources and circumstances. Adaptation, not supremacy, is thus a key concept [22,24-26].

The transformation of the idea of the great chain of being is not as obvious. According to Lovejoy (1936) this idea was a dominating figure of thought before the theories of evolution were presented in the 19th century [27]. Today there is a similar metaphor in ecological theory, in which everything existing is situated within complex ecosystems. These "chains" or systems of being are, however, seen neither as hierarchical nor static structures as they were in pre-modern times [28]. As this article will show, we have found that the conflicts in the environmental debate concerning intensive forestry and fertilization are mostly between agents of the progressive figure of thought and the decay figure of thought. The idea of the great chain of being has been somewhat intertwined with both of the other two figures but most of all with the idea of decay [29].

2.3. Method

Hence, in this article the real figures of thought are to some extent used in a deductive manner, *i.e.*, as tools to give structure to our analysis. Our way of methodologically sifting the argumentation of a debate for underlying figures of thought is rather straightforward. We look for elements in the argumentation which relate to a broader framework within which forest fertilization is understood by the opposing sides in the debate. The arguments are to a large extent directed towards the opposing side in order to further justify the position taken. These statements never concern forest fertilization *per se*. They underline a conception of how the world is structured and therefore have an implicit impact on how forest fertilization is understood. Elements, which constantly recur during the time period under investigation, are gathered together by us and constitute the figures of thought.

We then compare the current figures of thought in the debate to what Asplund refers to as the real figures of thought: the idea of progress, the idea of existence as a great chain of being, and the idea of decay. Thus it is possible to identify elements of the real figures of thought in the current ones. If so, we can, according to Asplund's theory, state that the current figures of thought are just transformations of real figures of thought that have survived through time and are still present in their transformed form.

2.4. Material

The empirical data consists of written sources from which points of view and ideas have been extracted through analysis. The source material consists primarily of journals and annuals distributed by non-profit associations that have set the tone of the debate on forest fertilization. We selected the

Swedish Forestry Association's magazine *Skogen* ("the Forest") as representative of the forestry industry's view and the Swedish Society for Nature Conservation's (SNF) magazine and annual *Sveriges Natur* ("Nature of Sweden"), as well as its youth organization Nature and Youth Sweden's magazine *Fältbiologen* ("Field biologist") to represent the point of view of the environmental movement. Common for these associations is that they have represented a large number of members and have been engaged as referral bodies (either directly or indirectly) during the consideration of forest fertilization-related questions by governmental committees. By systematically working through issues from each magazine from the 1950s to 2010, we have gained a solid insight into how the debate has shifted, as well as an understanding of what has remained stable and not changed. The initial examination of these magazines led us further to individual articles, polemical books and study material in which the forestry industry's methods have been debated.

We have also examined material published by the Foundation for Plant Nutrition Research and its Committee for Plant Nutrition in Forests. Its materials are archived at the Royal Swedish Academy of Agriculture and Forestry in Stockholm. Finally, we have examined a number of governmental studies into and reports concerning forest fertilization. In this article, we have specifically chosen to draw attention to the opinions published in the 1973 forestry report *Skog för framtid* (SOU 1978:6) ("Forest for the Future") [30], as well as the report *Möjligheter till intensivodling av skog* (MINT) ("The Potential for Intensive Forestry") [13], produced by the Swedish University of Agricultural Sciences (SLU) in 2009. In this way, we are able to examine and discuss the arguments and figures of thought that were prominent in the debate in the 1970s and compare them with those that exist today.

3. Results and Discussion

3.1. Early Interests in Forest Fertilization

Swedish research into nutrient conditions on forested land began during the 19th century and became the subject of increased interest around the turn of the 20th century. As a result of the Swedish state's increased interest in forest growth, the Swedish Institute of Experimental Forestry (Statens Skogsförsöksanstalt) was opened in Stockholm in 1902 (from 1902 to 1905 the institute was known as Forstliga Försöksanstalten and after 1945 as Statens Skogsforskningsinstitut). Early in its history the institute was divided into two separate divisions: a forestry division that dealt with matters related to forest management and a scientific division that focused on botany and pedology (this division was later re-named the Division of Botany and Pedology) [31]. Each division was headed by a professor from a relevant field of research. One of the first tasks assigned to the institute's researchers was to immediately investigate how forested land should be managed and cared for in order to give the highest possible timber yield [32].

In 1906, botanist Henrik Hesselman (1874–1943) began his work at the institute, eventually becoming head of the scientific division in 1912. From 1909 onward, Hesselman headed up experiments conducted at Degerö Stormyr, which lay inside state-owned forest land at Kulbäcksliden, close to Vindeln in Västerbotten County. In the decade that followed (1910 to 1920), Hesselman's pupils—botanist Carl Malmström (1891–1971), geologist Olof Tamm (1891–1973) and plant biologist Lars-Gunnar Romell (1891–1981)—also began to work at the institute as assistants, each of them

specializing in the biological conditions found in forested land. Two of their main areas of interest were studying nitrogen transformations in the soil and the importance of minerals. A large number of their experiments were performed at Kulbäcksliden and nearby Svartberget, both of which were designated as experiment parks for use by the Swedish Institute of Experimental Forestry in 1923. Their applied soil biology research laid the scientific foundation for different silvicultural methods that began to be implemented on a large scale during the 20th century, fertilization being among them [33].

Additionally, activities conducted outside the institute also played an important role in the eventual adoption of forest fertilization. Among some of the early experiments with fertilization were those conducted by forest officer Vilhelm Ålund on drained peatlands owned by the Robertsfors AB company. In the spring of 1910, Ålund began fertilization experiments around the Robertsfors area using wood ash. Subsequent fertilizations were conducted in 1913, 1918 and 1926. These later experiments (which were made on Södra and Norra Hällmyran, west of Robertsfors) caught the attention of Carl Malmström in the early 1930s, who later published an account of the attempts, making them widely known throughout the forestry industry at large [34,35].

Fertilization and soil liming was also attempted at a site just outside Långbanshyttan by Filipstad in Värmland County, Sweden, in the beginning of the 1900s. These experiments were documented by local mine superintendent Hugo Viktor Tiberg, who also owned tracts of forested land. Correspondence between Tiberg and Ålund reveals that the two exchanged ideas on fertilization. Unlike Ålund, Tiberg published a number of writings on the subject, including *Skogsproduktionen på kemisk grundval* (1907) ("Forest Growth Using Chemicals") and *Skogsproduktionen, markläget och jordanalysen* (1910) ("Forest Growth, Soil Conditions and Soil Analysis") [33].

The afforestation of peatland was the primary focus of these early fertilization experiments, thus fertilizers other than nitrogen were most commonly applied. The industrial manufacture of nitrogenous fertilizers using electrochemical methods did not become possible until the beginning of the 20th century. Pioneers in this field included Norwegians Samuel Eyde (1866–1940) and Kristian Birkeland (1867–1917), who laid the foundation for the work done at Norsk Hydro-Elektrisk Kvælstofaktieselskap (Norwegian Hydro-electric Nitrogen Ltd., now Norsk Hydro ASA) in 1905. Norsk Hydro (now de-merged to create the separate fertilizer company Yara International ASA) soon became one of the dominant companies within the growing synthetic fertilizer industry. In 1907, the Swedish-based company Stockholms Superfosfatbolag began production of nitrogenous fertilizer using the same method applied by Norsk Hydro. Between 1910 and 1920, the company's operations expanded to include electrochemical factories in Ljungaverk, Trollhättan and Porjus, Sweden. Then, in 1940, a larger facility was established in Stockvik just outside Sundsvall, Sweden [36,37]. This development resulted in a large swell in commercial interest in the plant at both the national and international level during the first half of the 20th century, which, presumably, was influential in seeing the use of nitrogenous fertilizer increase. Naturally, the expansion also entailed greater opportunities to fertilize using nitrogen within both the agricultural and forestry industries.

The fact that fertilization of mineral soil forested land using nitrogenous fertilizer was interesting from a production perspective was exemplified in the 1930s when Hesselman and Romell established that addition of ammonium nitrate in old-growth spruce forests in northern Sweden radically increased the diameter of the tree trunks over a ten-year period [38]. However, it was not until the 1950s that the Swedish Institute of Experimental Forestry began to conduct more controlled fertilization experiments

on a larger scale on both mineral soil and peatland. Fertilization experiments were conducted on state-owned, commercially-owned and privately-owned land all over Sweden from 1951 onwards [39]. By this time, Carl Olof Tamm (1919–2007, son of the aforementioned Olof Tamm) had begun his academic career within soil science and, more specifically, within plant physiology. The younger Tamm first became an assistant (after successfully defending his thesis at Stockholm University in 1953) and later, in 1957, a professor in botany and pedology at the Institute of Experimental Forestry [40]. He immediately became the most frequently cited expert in questions of nitrogen fertilization, at least in the magazine *Skogen*.

The period stretching from approximately 1952 to 1960 can be defined as an initial phase in which the potential applications of forest fertilization were further discussed and investigated by researchers and practitioners working together. A practical step towards fertilization was taken at the close of the 1950s, when forestry companies began to experiment with the practice on a large scale. During 1957 and 1958, Chief Forest Officer Fredrik Ebeling and Research Officer Börje Häggström of the Swedish Forest Service set up their own fertilization experiments in southern Norrbotten County, in consultation with the Institute of Experimental Forestry and the Royal Swedish Academy of Agriculture and Forestry's (KSLA) Committee for Plant Nutrition in Forests, which had been established in 1956 [41]. Concurrently with this experiment, Swedish company Svenska Cellulosa AB (SCA) began fertilization experiments on its own lands. These experiments became so extensive that one of the employees responsible, Chief Forester Björn Hagström, referred to them as "close to full-scale fertilization" [42]. SCA would soon distinguish itself as the largest user of fertilization among the major forestry companies in Sweden (e.g., [43]).

A memorandum written on SCA's fertilization experiments in 1957 (preserved in the archive of KSLA's Committee for Plant Nutrition in Forests) reveals that SCA representatives had travelled to Norway in 1956 to observe successful fertilization experiments conducted on drained marshes by Egil Berg in Sokna. SCA later set up its first fertilization experiments on its own drained peatlands. A number of experiments on mineral soil were to follow. Although SCA drew inspiration from its Norwegian counterparts, its experiments were set up in accordance with the guidelines suggested by KSLA's Committee for Plant Nutrition in Forests and in consultation with professor Carl Olof Tamm and forest botanist Erik Björkman (1912–1973) [44,45].

By the early 1960s, forest fertilization seemed to have been proven as both practicable and economically justifiable. In summary, the experiments demonstrated that the trees that were most important to the Swedish forestry industry (pine and spruce) were able to absorb the nutrients in fertilizers and thus achieve greater growth. The research conducted had also proven that there was a lack of nitrogen in all forest stands with the exception of those that stood on the most prime lands in southern and central Sweden. As such, on nearly all mineral soil, fertilization with nitrogen resulted in a production increase that continued for approximately ten years after fertilization had been conducted. Carl Olof Tamm and his colleagues suggested that it was appropriate (first and foremost) to fertilize older stands planted on mineral soil that would be logged within a relatively short period of time. This measure was believed to be an effective way to improve the standing stock's yield [46-50].

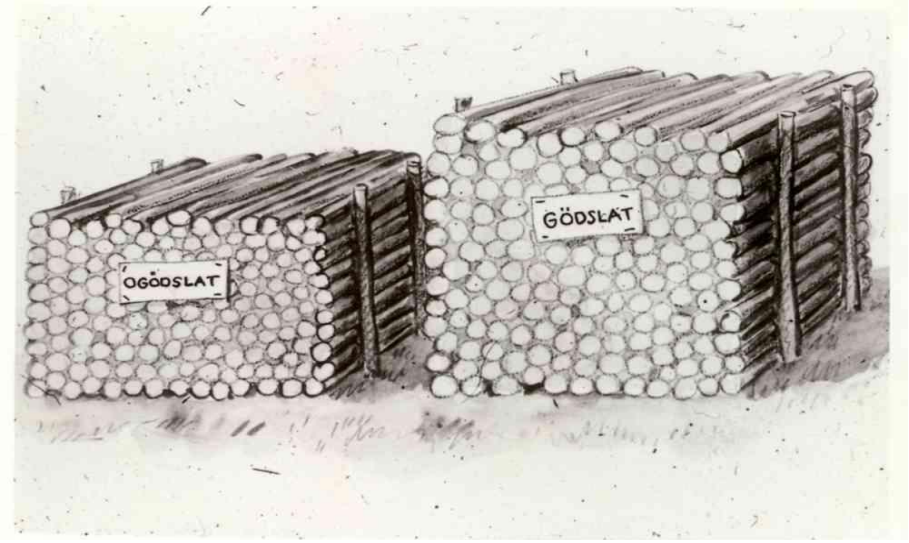
3.2. Forest-fertilization Discourse Established

As previously mentioned, interest in forest fertilization increased significantly in Sweden during the 1950s. Not only did the practical experiments increase in scale and begin to involve a large number of Swedish forest owners, but there was also a similar increase in the dissemination of information about forest fertilization, particularly within the internal information channels of Swedish forestry. As such, it can be said that a "forest-fertilization discourse" was established at this time. Both KSLA's Committee for Plant Nutrition in Forests and other trade associations and industry organizations, such as the Swedish Forestry Association (then known as Svenska Skogsvårdsföreningen, now Föreningen Skogen) and Gödslings- och kalkningsindustrins samarbetsdelegation (GKS) ("the Fertilization and Liming Industry's Joint Committee") actively participated in formulating and promoting the new method. In cooperation with several state agricultural organizations, the latter of the aforementioned organizations published and distributed the magazine *Växtnäringsnytt* from 1945. Carl Olof Tamm published a number of his scientific discoveries in these trade organizations' magazines during the 1950s and early 1960s [51-54].

The "forest-fertilization discourse" came of age in 1962, when the Swedish Forestry Association's annual conference "Skogsveckan" ("Forest Week") adopted forest fertilization as its theme and KSLA's Committee for Plant Nutrition in Forests organized a major conference at the Royal School of Forestry in Stockholm, at which delegates from Sweden, Norway and Denmark discussed both the effects of fertilization and its possible consequences [35,55]. Forest fertilization also began to be included in official public forestry statistics in the same year [56].

Why did interest in fertilization increase at this time? One explanation offered by the forest industry itself was that it was a result of the realization that the amount of timber existing in Sweden at that time had ceased to be sufficient to cover the domestic cellulose industry's increasing need for raw materials. Swedish cellulose factories expanded and rationalizations were implemented during the 1950s that resulted in factories being able to produce significantly higher volumes than previously. Behind these efforts (which also occurred in the rest of Scandinavia and North America) lay promising prognoses that suggested that the consumption of paper and cardboard in Western Europe would increase dramatically in the following decade. The only problem was that the production of the raw material could not keep pace with the expected increase in demand. In other words, forests were seen as a bottleneck in the production process. According to estimates by paper producer SCA, production capacity would allow the production of 75% more pulp in Sweden in 1963–1964 compared with 1955–1956, but that the availability of wood could only increase by 30–40% during the same period. In order to fill the supply gap from its existing resources, SCA had already begun to purchase wood from other forest owners within Sweden and from foreign sources. It was at this time that forest fertilization presented itself as an alternative to the need to purchase timber from external sources (Figure 2). Perhaps it would be possible for the forestry company to increase its profits by fertilizing its way to the higher yields needed for its own pulp factories. Given the situation it found itself facing, SCA's forest fertilization experiments aimed to determine how forest owners could maximize timber yields for invested capital by comparing types of fertilizer, volumes, intervals and other variables against one another [35,42].

Figure 2. Illustration showing the difference between a timber harvest from a non-fertilized forest (to the left) and a fertilized forest (to the right). Source: Supra AB's Archive, Skånes Näringslivsarkiv, Helsingborg, Sweden. Painter unknown.



A number of other general explanations for the popularity of forest fertilization can be added to the commercial motivation noted above. In addition to practical financial and technological conditions, organizational and cultural conditions are also required for an innovation such as fertilization to achieve the kind of breakthrough it did at this time [57]. Apart from the fact that the range of nitrogenous fertilizers available increased during the first half of the 20th century, science proved that nitrogen fertilizers promoted tree growth in forests in an economically feasible way. Another contributing factor was the newly institutionalized desire within the forestry industry to work using large-scale methods and modern technology. One step towards working in this manner was taken in the Swedish Forestry Act of 1948. The act tightened regulations on regeneration and final felling as a means by which to increase timber production and ensure the growth of the industry. The idea was that with the help of the revised law, a sustainable forestry industry with a stable yield would be achieved [9,58,59].

Forest fertilization was introduced together with a host of other measures that we now associate with modern forestry. Among the most important of these were the clear-cutting, the use of chemical biocides (DDT and phenoxyacetic acids/Hormoslyr), mechanical scarification and afforestation using fast-growing tree species (later, during the 1960s and 1970s, primarily lodgepole pine, *i.e.*, *Pinus contorta*). The fact that the Swedish export industry was booming at the time created favorable conditions for this shift. The need to reconstruct Europe after World War II, followed by the "Korean Boom" from 1950 to 1952 provided both the resources and the optimism needed to propel the forestry industry forward [59,60]. Sweden was not alone in this development. However, compared with Germany and Norway, for example, development in Sweden occurred at a very rapid pace [60,61].

Yet another step in the direction of intensified, modern forestry was taken in the form of the policy decision by the major forestry companies to "restore" their forest resources. Modern methods became more popular as the forests that had been either felled to a diameter limit or selectively cut in the early

20th century were in line to be "cleaned up". This applied primarily to areas in northern Sweden, where forest cultivation had been neglected [9,59].

The major investment in intensified forestry using modern methods of management would hardly have been possible if the necessary financial resources, technological advances and cheap oil had not been available. Using Asplund's term, it can be said that it was this "topsoil" of favorable material conditions that set the stage and allowed the "forest-fertilization discourse" to take root and begin to grow. What did the mediating figures of thought look like at that time? Judging by earlier research, an optimistic "idea of progress" dominated this period and few questioned it, even when critical concerns were expressed [21].

The fertilization discourse's figures of thought can also be traced back to the 1800s and the development of modern agricultural science and forest science. Earlier research has shown how the idea of "increasing humanity's share of nature's gifts by 'steering' natural laws in a direction that favors man" lay the foundation for agricultural research as a whole. Fertilization theories and experiments were primarily designed for the purpose of creating a farm that produced greater yields without depleting the soil [36]. This goal became central in forest science, also, especially within silviculture. Even as early as 1828, when the Swedish Royal Institute of Forestry was established at Djurgården, Stockholm, its director, Israel af Ström, promoted the idea that forests should be cultivated in the same way as a field—via a process of sowing, maturation and harvest [62]. From there, it was no great leap to examining ways of improving forestry's yields through such measures as fertilization. Since this time the farming metaphor has been central within the forestry industry and has been used in defense of its methods in the hope of winning greater acceptance, by claiming that they are the same as farmers. At the same time, farming has also often been used as a contrasting counterpart to forestry by commentators within the industry. This is especially true in the debate over chemical use, in which it has often been pointed out that forestry's chemical emissions are negligible compared with that of farming, and that any critique in this regard should be leveled squarely at agriculture [43,63-65].

3.3. Risks of Forest Fertilization

In the early 1960s, when forest fertilization had gained popular acceptance within forestry research circles and the forestry industry, other stakeholders directed criticism towards modern society's use of chemicals both within Sweden and abroad. The threat of unseen environmental destruction in the form of air and water pollution found its way onto political and scientific agendas, as well as into the consciousness of the mass media and environmental groups, such as the Swedish Society for Nature Conservation and Nature and Youth Sweden [25,66]. As a result, the dominating figure of thought during the 1950s, "the idea of progress", with its strong faith in humanity's ability to increase and process the earth's resources, was forced to cede ever more ground to an anti-growth figure of thought that instead turned the spotlight on concerns for the earth's limited resources and the survival of the planet, *i.e.*, "the idea of decay" or "the ageing world" (see also e.g., [22]). In light of this shift in attitude, forest fertilization began to be called into question.

Early comments from the forestry industry's internal discussions on forest fertilization reveal evidence of concern that human interference with nature may lead to unforeseen, negative consequences. One suspects that researchers and foresters were influenced by the growing criticism of

the idea of progress. However, the concern expressed was not related to the ramifications of fertilization for human and animal life, but for the forests' long-term production capabilities and, in the long-run, the forestry industry's financial viability. As an example, as early as 1962, pulp and paper company SCA's spokesperson Björn Hagström posed the question to researcher Carl Olof Tamm as to whether or not fertilization could have any as-yet-unknown, negative consequences:

> […] does anything else happen? Is it possible that something undesirable might happen? In the discovery of fertilization, have we achieved something that, in the long-term, will destroy the land or reduce its production capacity? Have we upset the biological balance or made some other serious mistake? [67]

C.O. Tamm was able to give a reassuring response. In his opinion, the amounts of nitrogen added to the soil were so minuscule that they "likely" posed no danger at all. On the other hand, Tamm did point out that the methods used by the forestry industry were not entirely risk-free:

> However, it should be noted that introducing artificial substances always entails a certain risk. It has been observed on many occasions that, when people have done so, it has led to completely unexpected consequences. As such, I would like to say that I am more concerned about the forest ditching than fertilization, although the dangers of ditching should not be unduly overstated either. However, in the case of forest ditching, one is making an irreversible change in the natural conditions [67].

Even though it was the forest's production capacity that lay at the heart of the industry's questions about fertilization's feasibility, a certain sense of humility in the recognition that the industry's practices could lead to harm was also in evidence, as was the knowledge that the long-term consequences were still only insufficiently understood. The discussion shows that those parties with vested interests in forest growth took a pro-environment position, albeit an anthropocentric one, *i.e.*, that their concern related to the careful use of nature's resources for the sake of humanity and society (for more on anthropocentric *versus* biocentric ideas, see e.g., [26,68]). Nevertheless, from the forestry industry's standpoint, the conclusion was that fertilization was a risk worth taking. Behind these arguments we thus see representations of both the idea of progress and the great chain of being, *i.e.*, in the concern expressed regarding human impacts on the environment as a system.

It was not until 1965 that the idea that large-scale forest fertilization might have negative consequences beyond the forestry industry began to be expressed. At that time, the main concern was the possible poisoning of forest birds by grains of fertilizer—a concern which led the Swedish National Veterinary Institute, and what is now known as the Swedish University of Agricultural Sciences (SLU), to begin investigations into the matter. According to Stig Hagner, chief forester at SCA 1964–1991, at around the same time, cases in which cows had been poisoned by fertilizer spread in the forest were also reported. The cows, which had been grazing in the forest, ingested urea spilt during fertilization and subsequently died of ammonia poisoning [69]. That this could indeed be a problem was confirmed in an information leaflet published by Norsk Hydro in 1965. The leaflet contained instructions about how to prevent this from happening:

> Animals that are allowed free access to fertilizers are very inclined to eat them because of their salty taste. This is especially true of grazing animals, which, as such, are exposed to a

serious risk of poisoning. Don't leave any half-full sacks or piles of spilt fertilizer out on your land! The fertilizer is not harmful when it has been well spread out and the grains have fallen down between moss and shrubs [70]. (See also Figure 3)

Figure 3. Airfield and fertilizer depot in a Swedish forest. Recommendations on how to store fertilizers to prevent poisoning of animals were announced in the 1960s. The spreading of fertilizers by aircraft was common until the early 1980s when it was succeeded by the helicopter. During the 1990s spreading by tractor became the most common practice [29]. Source: Supra AB's Archive, Skånes Näringslivsarkiv, Helsingborg, Sweden. Photographer unknown.

At the close of the 1960s, forest fertilization's contribution to the pollution of surface and ground water also began to be the subject of attention among researchers and the growing environmental movement. The issue was raised in earnest in 1968, a year when also a European Water Conservation Campaign was presented by the Council of Europe [71]. In one of the first information booklets distributed by newly formed, semi-governmental research institute, the Forestry Research Institute of Sweden, Göran Möller discussed the question of fertilization's effect on water. The first debate about forest fertilization published by the Swedish Society for Nature Conservation appeared in its magazine at the same time. The debate was held between agriculturalist Kjell Arman and Erik W. Höjer of the Swedish Forest Service. Arman spoke out strongly against forest fertilization, citing it as yet another example of the forestry industry's practice of "violently attacking" nature. He warned primarily against the long-term effects of fertilization on the biological conditions needed for growth on forested land and, in doing so, linked his argument to the debate that had been going on internally within the forestry industry itself [72]. Höjer replied that a great deal of research was still required in order to be able to fully understand the risks associated with fertilization and that environmental research needed to be introduced alongside production research [73].

In the end, however, Höjer's argument was that, at that point in time, there were no known detrimental effects caused by fertilization and that, as such, the practice would continue to expand. The optimistic belief in humanity's abilities, in "progress", was tangible: "[Forest fertilization] will

increase as the discoveries made with each year are added to those of previous years and the certainty of the assessment of its effects increases." [73]. That is, the foundation of his argument was that increased research entailed a reduced risk and increased safety with regard to fertilization. The fact that research could also contribute to the discovery and understanding of new risks, so that uncertainty rather increased, is a thought that does not seem to have crossed Höjer's mind.

3.4. The Struggle Intensifies in the 1970s

The questions surrounding forest fertilization put forward during the 1960s, *i.e.*, with regard to the short- and long-term effects on soil and water, as well as the questions concerning poisoning, carried over into the 1970s. The new Swedish Environmental Protection Act of 1969, which targeted environmentally hazardous operations, gave additional incentive to undertake comprehensive research projects that investigated the environmental impact of fertilization. The first of such investigations began in 1969, led by the Swedish Environmental Protection Agency (The Swedish EPA, which had been established two years earlier), on behalf of the Swedish Forest Service. Questions concerning soil and water were central to this investigation [74].

In spite of research efforts on the effects of forest fertilization on the environment, public opinion was not quieted. Instead, this was when the debate truly intensified and when relations between the environmental movement and the forestry industry became more contentious.

Public criticism of forest fertilization can be traced to the summer of 1971, when three cows were reported poisoned by fertilizer in Brattfors, outside of Filipstad in Värmland County. The news of the event made immediate headlines in the local social democratic newspaper *Värmlands Folkblad* and in the conservative newspaper *Nya Wermlands-Tidningen*, from which point the story spread further. In August of the same year, there were additional reports concerning bee die-offs, blind or dead fish, and mysterious bird deaths in the same region. It was also reported that a number of domestic animals had fallen ill. The public and the media linked these events with forest fertilization from the early summer and the local municipal public health boards condemned careless fertilization by the forest-owning companies [75-84].

In response, an informational campaign was launched by the forestry industry to try to sway the environmental movement, politicians, journalists, teachers and school students. Its intent was to increase understanding for modern forestry and the benefits it provided Sweden [9]. What was achieved was hardly the desired result, however. Instead of being appeased, the environmental movement began to increasingly criticize the forestry industry in the magazines it distributed to its members. The respective sides in the debate published several controversial books on the subject, study materials and statements of policy, concerning the forestry industry's methods.

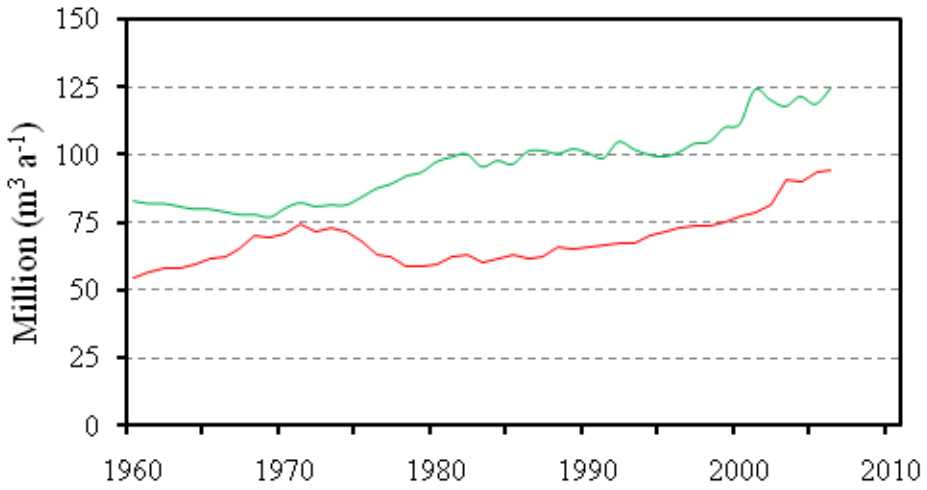
While this was happening, forest fertilization also began to find its way onto the political agenda. The Ministry of Agriculture began two investigations—one into clear-cutting and one into the spreading of chemical agents. The latter examined both agriculture's and forestry's use of biocides and synthetic fertilizers [7]. No serious restrictions, however, were placed on forest fertilization, and its use increased to its highest level ever during the decade, reaching its peak in 1976–1977. The debate was reignited in conjunction with the work to prepare the new Forestry Act in 1979.

3.5. Central Arguments and Figures of Thought in the Debate during the 1970s

A closer analysis of the debate between the environmental movement and the forestry industry during the 1970s allows us to trace the figures of thought involved.

One condition that both stakeholders based their arguments on was estimates showing that annual felling together with the total loss was either on par with or exceeded the annual increment of timber in Swedish forests. Current forestry statistics confirm that gross harvest temporarily reached a higher level around 1970, just when these concerns arose (Figure 4). Based on this "material reality", both groups expressed differing arguments and conclusions that, in turn, using Asplund's model, can be linked to the fact that the two groups embraced different figures of thought.

Figure 4. Annual volume increment (green line), and gross harvest (red line) in Swedish forests 1960–2006 (standing volume including bark). Note: All values are five-year averages [85].



For the environmental movement, the conclusion was that forestry-based industries had an overcapacity and that forestry practices should be adjusted to suit the ecological circumstances. According to the environmental movement, attempts to regulate nature according to the forestry industry's financial circumstances using different methods that accelerated forest growth amounted to an "impossible equation" [8,86,87]. This opinion became more entrenched after the 1979 Forestry Act was adopted and it continued to be voiced throughout the 1980s (e.g., [88-95]). This fundamental attitude fitted well with "the idea of decay" as well as the idea of nature as a "great chain of being". Other statements about how mankind is unable to control the entire ecosystem and through interference instead risks causing irreversible changes can also be seen as an expression of these figures of thought:

> Many of these methods are entirely new for the forestry industry and their impact on the forest's ecosystem is not yet fully understood. It must be viewed as rash to accept such extensive changes to our natural environment, given that we do not know what the long-term ecological consequences of these changes will be. The mistakes that we make

> today as a result of our lack of knowledge will likely prove to be completely irrevocable at some point in the future [96].

In this we see the biocentric idea that nature works best and offers humankind the greatest return if it is allowed to manage itself. In accordance with this statement Nature and Youth Sweden further declared that humankind had two alternatives: to accept its role in the ecosystem or to sabotage the system in an attempt to extract more from nature than it had been allocated. The American ecologist and politician Barry Commoner and his theory on the "four laws of ecology" from 1971 were cited in support of this argument [97].

The damage forest cultivation could cause to the soil, and how manipulation of the ecosystem might in fact harm the progress of the forestry industry itself, were also discussed. The misgivings and uncertainty expressed by stakeholders in the forestry industry in the early 1960s [67] thus became cornerstones of the environmental movement's criticism of fertilization in the 1970s [8,86,87]. One could claim that the environmental movement, as a strategy to be able to communicate with the other side, borrowed a central argument from the industry that was based on the progressive figure of thought.

Based on the arguments presented above, in 1973 Nature and Youth Sweden published a policy statement aimed at halting forest fertilization and the use of ploughing, the chemical treatment of broad-leaved trees, the promotion of monoculture, the use of insecticides and the introduction of foreign species. It also argued for the regulation of clear-cutting by means of legislation [96].

The Swedish Society for Nature Conservation published a similar policy statement in 1978. The principal aim of this policy was to define the necessary requirements for the creation of a forestry industry with an "ecological focus" [8]. The policy included such requirements as the industry giving consideration to the various stakeholders and generally taking in account environmental factors in its operations, that is, requirements that would later garner broad support in the forestry and environmental political debate of the 1990s. Forest fertilization would not be part of a forestry industry with an ecological focus, the Swedish Society for Nature Conservation contended. It supported its position by stating that the by-now confirmed environmental risks (the temporary poisoning of water supplies, eutrophication, the leaching of other nutrients from soil, the effects on the soil's microfauna and on ground cover, *etc*.) should be considered as being of greater importance than short-term financial benefits. A new, global justice argument founded on the notion that fertilizers were in short supply and should be used economically was also cited: "From a global perspective, it is more important to use fertilizer for agriculture" [8].

The forestry industry and the environmental movement drew completely different conclusions. While the environmental movement, based on its own figures of thought, believed that it was unreasonable to allow the forestry industry's need for raw materials to determine the growth of the forests, the forestry industry, based on "the idea of progress", considered that, in fact, this approach was both possible and desirable [98]. In this we see the critical difference between the environmental movement's and forestry industry's arguments for and against fertilization during the 1970s.

The arguments in favor of increasing growth with the help of fertilizers were primarily economic. The forestry industry's importance for the Swedish economy and, above all, for employment in northern Sweden's inland region was a recurring argument for allowing demand to determine industry

practices. The effect of fertilization translated directly into hard figures. If a total ban on fertilization was implemented, then the major forestry companies would immediately be forced to cut back their cutting yield. This would impact not only individual companies, but also individual workers, economically weak regions and the nation's economy as a whole, *i.e.*, the common good:

> We currently fertilize just over 100,000 hectares, which is equivalent to an annual production increase of more than one million m^3. Prohibiting fertilization would have the immediate practical effect of the firing of around 800 fulltime employees within the industry, as well as the loss of 150–200,000 tons of raw material annually for the pulp industry. What this would mean for the national economy and in purely human terms for an already hard-pressed industry should be assessed by those with greater qualifications in such matters than what I possess. One should remember, however, that the difficulties that would arise would, above all, affect those parts of our country where commerce has historically been highly undiversified [65].

With regard to the environmental risks, the forestry industry's spokesperson drew the same conclusions as had been put forward in the 1960s. There was an awareness of the risks, but instead of reducing the degree of risk-taking until research and experience could prove that different practices were not harmful, as the environmental movement proposed, the forestry industry adopted the position that forestry could continue as long as no damage could be conclusively proven. It was said that those companies practicing fertilization were monitoring results of ongoing scientific investigations into the effects of forest fertilization on the environment and that, as such, they could quickly modify their practices if necessary. Here we see an idea expressed that is reminiscent of what later would be called "adaptive management", about which more information follows below [98]. In defending itself again the accusations leveled by the environmental movement and the periodically upset public, the forestry industry pointed out time and again that the risk of over-fertilization or poisoning had been exaggerated. There would be no problem so long as the industry followed the instructions prescribed [65].

To summarize our impressions of the debate of the 1970s, the spokesmen of forestry based their arguments on a progressive figure of thought that was constituted as follows:

> The Swedish forestry business generates a lot of jobs and large export revenues. Any restrictions for forestry and forestry business are therefore a threat to the national welfare and economic growth [29].

Opposed to this figure of thought was the environmental movement's more reluctant figure of thought related to an environment in danger or decay:

> The earth's resources are finite. Therefore the ecosystems are not able to deliver utilities for human consumption above their natural capacity without endangering the future. Unchecked consumption and ever increasing economic growth are not feasible [29].

As will be shown in the next section, these divergent arguments and figures of thought were also reflected at the level of national politics.

3.6. Attitudes towards Intensified Fertilization 1978/1979

In 1979, Sweden passed the Swedish Forestry Act (1979:429), which replaced the previous Forestry Act from 1948. In the preliminary work on the bill, even more intensive forestry with more extensive forest fertilization was discussed. Today, a similar discussion is taking place within forestry-related policy and governmental committees. In order to determine to what extent ideas about forest fertilization have remained stable or have changed, we have chosen to compare the different investigations with one another.

The investigation that preceded the 1979 Forestry Act focused on the industry's need for raw materials. It was this consideration that lay behind the committee's presentation of three alternative production programs for the forestry industry of the future. All addressed the question of forest fertilization. In brief, it can be said that Alternative 1 pointed in the direction of unchanged forestry practice in accordance with the principles and level of intensity that prevailed at the time. Alternative 2 was called "sustained level of felling at good stands together with an ambitious forest production program", and recommended a dramatic intensification of forestry in order to meet the need within the forestry industry. This alternative assumed an increase in forest fertilization to cover 450,000 hectares during the 1990s. This level was then to be maintained for a century thereafter. The drainage ditching of swamp forests with possible fertilization to follow was estimated to reach an area of 900,000 hectares and the drainage ditching and fertilization of wetlands to approximately 1.3 million hectares between 1980 and 2020. Comprehensive afforestation using lodgepole pine was also recommended. The hope was that a program such as this would increase annual gross felling from 75 million m^3 to 80 million m^3 as early as the 1980s [30].

Alternative 3 was unofficially dubbed the "nature conservation alternative" and entailed less intensive forestry than was practiced at the time. This alternative included restrictions on the use of chemical biocides, fertilization and ditching. According to the investigation, this would lead to a reduction in gross felling. The volume of hardwood timber was expected to increase by 70% over the course of a 100-year-period at the expense of the lucrative conifers. Only 75% of industrial capacity could then be used. Alternative 3 would thereby have an immediate, negative impact on employment and income derived from exports, the committee members explained. The committee itself advocated Alternative 2 as its choice [30].

The clear difference in opinion that prevailed in the 1970s is evident in referral bodies handling of these proposed alternative production program. Here it is clearly apparent which stakeholders stood on which side of the debate with regard to both forest fertilization and other issues.

Of the 67 referral bodies that responded, 17 were positive towards intensified forestry as proposed in Alternative 2. (The complete list of the referral bodies and the distribution of their responds is presented in Appendix 1). This group was primarily composed of representatives for timber growth and employment interests at the level of public authorities and private business: The Foresters' Cooperation Committee, forest services provider Skogssällskapet, The Swedish Forest Service, the Swedish National Board of Agriculture, the Swedish National Labor Market Board, forestry industry labor unions, the Forestry Research Institute of Sweden and the Swedish University of Agricultural Sciences (SLU). Several bodies expressed certain reservations, however. For example, Skogssällskapet had reservations about extensive afforestation using lodgepole pine and the labor unions stated their

position that any intensification on the part of the forestry industry should not be made at the expense of workers' health [99]. The Swedish Forest Service stood out as particularly optimistic. Its representatives advocated without reservation the use of DDT dip-treated seedlings, the continued use of phenoxyacetic acids, fertilization via coordination with individual forest owners, ditching programs including fertilization and the increased planting of lodgepole pine. There was one member of the Swedish Forest Service's management group, however, who expressed reservations about the continued use of DDT [99].

The majority of the referral bodies—28 in total—had misgivings about the possibility of implementing Alternative 2. They cited financial and/or environmental reasons for their lack of confidence. Representatives for the individual forest owners, e.g., the Swedish Federation of Forest Owners, said that they were positive, in principle, towards Alternative 2, but that they did not believe that smaller forestry companies would be capable of intensifying their operations to the degree specified [99]. One major group among those who expressed doubt was comprised of the county administrative boards that were asked to give comment. Their statements were a combination of enthusiasm for intensified forestry born of regional political interest, the opinion that the expectations placed on small-scale forestry by the proposal were unrealistic and concern over the environmental consequences. Their responses also included further reservations from those who opposed the use of chemical biocides within forestry [99].

Eighteen bodies expressed strongly negative opinions towards Alternative 2 and forest fertilization. Those who fell into this group primarily described regard for the environment as their argument against intensified forestry, though to some extent they also cited regard for recreational interests, too. The bodies in this group included the Swedish Society for Nature Conservation (SNF), Nature and Youth Sweden and the Swedish Environmental Protection Agency (Swedish EPA). The SNF was so critical of the proposal that they practically rejected the entire investigation outright:

> The report is so poorly supported and the proposal for silviculture legislation so greatly formulated to the disadvantage of both environmental conservation and the forestry industry that the investigating committee's proposal cannot serve as the basis for making decisions about national forestry policy [99].

Above all, the SNF considered that the investigation had failed to include community needs other than those of the forestry industry into forestry policy. SNF and Nature and Youth Sweden desired to put a complete stop to all forest fertilization. Others who expressed their support of a complete moratorium on fertilization included Friends of the Earth Sweden and the Centre Party Youth League. The Swedish EPA, which shared a critical attitude towards the investigation, felt that fertilization should at least be avoided in the vicinity of urban areas. No direct reason was given as to why fertilization should cease. Conversely, an indirect reason for this position can be seen in one of the fundamental arguments presented by these organizations, namely that forestry and the forestry industry should adapt to suit nature's resources and circumstances, and not the other way around. Human beings did not have the right to manipulate nature in order to satisfy their own needs [99], *i.e.*, a notion related to "the idea of decay".

This basic principle was later given support by the national government, which also rejected the investigation's proposal for future forestry production programs. Instead, guidelines for forestry policy

were proposed that, while also focusing on the forest's production, did not specify intensification in such an obvious way. With regard to forest fertilization, the government did not consider that it was the state's place to encourage the practice. On the other hand, it was the state's duty to promote increased research into the impact of fertilization on the environment. Nonetheless, no limitations were imposed on the forestry industry's freedom to fertilize [99].

3.7. Attitudes Towards Intensified Fertilization 2009/2010

In recent years, the requirements for an increased timber production have returned to the political agenda in Sweden. It is the first time this has happened since the last major changes were made to the Forestry Act (1979:429) in the early 1990s. The forestry policy established at that time was a paradigm shift in the state's view of forestry's relationship to protection of the environment. A number of the demands by the environmental movement since the 1970s were realized at that time, among them the equal weighting of environmental and production targets for the first time ever. In practice, this should mean that general consideration should always be given to valuable habitats, aquatic ecosystems and cultural remnants in the forested landscape being worked [100]. At the same time, fertilization by the forestry industry declined radically for several reasons. In our investigation into the reasons for the variations in forest fertilization that have occurred over the years, it has been observed that the low level of activity that began after 1990 depended in part on the forestry industry's weakened financial state in the early 1990s, as well as on calculations that showed that timber resources were sufficient even without the use of nitrogenous fertilizers. Moreover, fertilization had also been in decline over a longer period of time due to the residual concern over its long-term effects on forested land and watercourses.

Concern about fertilization's negative impact increased during the early 1980s after researchers began to sound the alarm about extensive forest decline and dieback in Central Europe and Sweden [101]. For this reason, since 1984 recommendations (*i.e.*, SKSFS [102,103]) have been published by the Swedish Forest Agency on restrictions concerning the amount and location of fertilization using nitrogenous fertilizers in order to reduce the risk of further acidification, nitrogen saturation and the depletion of other nutrients in the forest soils, as well as the eutrophication of lakes, watercourses and seas. These recommendations began to have a greater effect on those forestry companies practicing fertilization in the beginning of the 1990s [102,103]. The same restrictions also came to apply with regard to the certification of wood in accordance with the Forest Stewardship Council's (FSC) standard, that was ratified in 1998 [104]. As such, for some period of time there have existed several reasons as to why forestry companies have cut back on fertilization.

The main provisions in the Swedish Forestry Act passed in the 1990s and the restrictive attitude towards forest fertilization still apply today. Today's basis for timber production intensification is thereby not the same as that used at the end of the 1970s, when restrictions were few and fertilization reached a peak of 190,000 hectares annually. At present, fertilization is practiced across approximately 60,000 hectares per year. Nonetheless, we believe that it is still possible to compare attitudes, and—above all—to discuss the influence of figures of thought on these attitudes by studying referral bodies' views on intensive forest fertilization both then and now.

The political shift in favor of more production-focused forestry was clear during 2006, when a number of governmental studies pointed to the need to increase timber growth and future felling (e.g., [12,105]). The motivation at this time was primarily an increased demand for bioenergy from forests, at the same time as the need for raw materials on the part of the traditional forest industry was expected to continue at an elevated level. A number of smaller studies then followed, including *Möjligheter till intensivodling av skog* ("Possibility for Intensive Forestry") (MINT) [13], which was set up during 2008 to more specifically investigate the possibilities for the future intensification of industrial forest growth, including measures such as fertilization.

The investigation suggests that to a greater extent than is possible presently, forest owners should be allowed to use vegetatively-propagated spruce (clones), lodgepole pine and a form of flexible fertilizing method, *i.e.*, "nutrient optimization", within the framework of "adaptive management", that is, a continual evaluation from the standpoint of the various interested parties. However, the adoption of these measures is expected to exceed current restrictions imposed on their use, including the amount of fertilizer allowed per hectare. The method of fertilization proposed differs from that of nitrogen fertilization in the 1970s (now known as conventional or traditional fertilization) in as much as that suitable, younger stands are fertilized with nitrogen and other plant nutrients with shorter cycle periods and according to "the amount and combination the trees are able to absorb without causing leaching into soil water". Increased conventional fertilization is, however, also being discussed [13].

How have the referral bodies responded in 2010? The grouping of referral bodies looks somewhat different in 2010 than in 1978/1979. (The complete list of the referral bodies and the distribution of their responds is presented in Appendix 2). The labor market interests that were so central earlier are not as clearly seen in the 2010 survey. The environmental sector has been strengthened by the addition of new representatives for environmental research and biological diversity in the Swedish Biodiversity Centre, established in 1994, and the Swedish Species Information Centre, which became a permanent division in 1991. The energy sector has also become a referral body through the Swedish Energy Agency and the Swedish Bioenergy Association (Svebio) [106].

According to the Ministry of Agriculture, a summary shows 22 of the 52 bodies that responded are predominantly positive, while 17 are predominantly negative and 13 have described themselves as either unsure or neither positive nor negative. As such, as compared with 1978/1979, a larger percentage of respondents have adopted a positive stance towards intensified forestry. A significantly smaller percentage of respondents fall into the group of undecided [106].

As in 1978/1979, stakeholders with a vested interest in timber cultivation are among those most unequivocally positive towards the study's proposal: the National Property Board Sweden and Sveaskog förvaltnings AB (formerly the Swedish Forest Service), the Swedish Forest Industries Federation and now also the Swedish Federation of Forest Owners, *i.e.*, representatives for smaller forest owners in Sweden. Among those most negative towards intensified forestry are organizations from the environmental movement such as the Swedish Society for Nature Conservation and WWF, as well as the new academic bodies the Swedish Species Information Centre and the Swedish Biodiversity Centre. One interesting change has occurred at the level of public authorities, however, in that the Swedish EPA has expressed a positive view towards intensified forestry, while the Swedish Forest Agency has adopted a negative view [106]. How are these positions justified? Which material

standpoints, central arguments and figures of thought can be seen in these decisions and in today's attitude towards fertilization?

3.8. Central Arguments and Figures of Thought, 2010

The current debate does not share the same basic concern as the 1970s, *i.e.*, that the number of trees felled annually and the demand for timber exceeded the forests' annual growth. Instead, it is the prospect of significantly increased *future* demand for raw materials that serves as the basis for debate. This expectation has resulted in pressure to adopt measures that will immediately facilitate increased timber growth in the forest. The belief in continued climate change, which to a large extent has become a common starting point for discussion within forestry and environmental policy-related debate, is behind this idea. Climate change has also caused attitudes towards the intensification of forestry to become more complex than they were in the 1970s. That concern of global climate change is the basis for arguments both for and against an intensified forestry means that all authoritative bodies are now in a way adopting a position towards the more hesitant figures of thought related to the idea of decay and the great chain of being.

In general, a greater number of critical viewpoints are found in statements issued by referral bodies today than was the case in 1978/1979. This is also true of even the most positive among them, although they still emphasize the progressive figure of thought (as does the committee's final report) by claiming that the opportunity to find a successful solution to both production and climate-related problems is of greater importance than the associated risks.

As in the 1970s, common to most organizations within the forestry sector is the belief that the measures proposed are beneficial for both business and the national economy. From this it would appear that, in the end, the opportunity to increase production and growth is the decisive factor. Even the references made in the 1970s to the national welfare seem to reoccur in essence here, although the explicit term "the common good" appears only rarely in official statements [107-111].

Otherwise, the responses given reveal strong disagreement concerning the scientific findings on a number of issues related to intensive cultivation and fertilization. Among these is the basic question of whether or not increased fertilization would be a positive step with regard to climate change or not, *i.e.*, whether or not these methods would really reduce the emission of greenhouse gases, or conversely, increase them. Those bodies that have adopted a positive stand towards intensification point out that both the climatic and the political targets established with regard to climate change would be supported by the proposed methods, among them the EU's target of increasing the use of renewable energy by 20 per cent by 2020. The Swedish Environmental Protection Agency stands alone, however, as the only body from the environmental side of the debate to adopt a positive stance on the issue [108,112,113]. Other representatives from the environmental camp are skeptical towards climate-related arguments and instead claim that intensified forestry and fertilization would increase the emission of greenhouse gases such as methane and nitrous oxide [114-116].

In general, critics of the proposal display a deep mistrust towards the eco-modern idea of using the proposed methods to promote both production and economic growth, while at the same time helping to stem the tide of climate change. The Swedish Society for Nature Conservation (SNF) believes, for example, that the study's climate-based arguments are both misleading and unrealistic. They claim that

Sweden will be able to manage the transition to alternative energy forms using forest resources as they exist at present. Instead, the SNF and other critics highlight those national environmental quality objectives [117] that would be contravened if the study committee's proposals were to be implemented. The international environmental directives said to be overstepped by intensified fertilization are primarily the agreements regarding improved water quality found in the EU Water Framework Directive and HELCOM's Baltic Sea Action Plan (BSAP), which include the establishment of targets for reduced nitrogen emissions into the Baltic Sea [112,114,115,118].

The increased number of international conventions and agreements has supplied the critics of an intensified forestry with new arguments as compared with 1978/79. International cooperation can be said to have created a discourse that concerns "Sweden's reputation". As one example, the Swedish Forest Agency uses this discourse in its claim that outsiders' view of Sweden could be negatively affected if intensified cultivation was introduced "across large areas" [114]. In addition, the fact that certain national environmental quality objectives in the committee's proposal conflict with other environmental objectives is something that referral bodies on both sides of the debate point out. A number of advocates of intensification (such as the Swedish EPA) stress, however, that the climate-related objective "Reduced Climate Impact" possibly should be given priority over the others [110,112].

Interestingly, there is also disagreement as to whether forest fertilization, and nutrient optimization fertilization, in particular, can be described as a scientifically proven method—as both the study committee and its advocates claim. Those who advocate fertilization believe that the results of research into the practice conducted thus far are adequate to initiate fertilization on a larger scale and to increase the practice of conventional fertilization again [13]. Those most critical of the proposal once again claim the opposite: that existing studies reveal an unacceptably high degree of negative impact on biological diversity, soil and water. As such, several decades of research in the area seems not only to have provided clarity, but also to have increased awareness of the complexity of the issue.

Once again, we see different interpretations with regard to risk and benefit. As previously noted, an awareness of the risks involved is seen in both camps, which, according to our interpretation, could be related to the idea of the great chain of being. It is the interpretation of how great these risks are that separates the two. According to the representative for smaller forest owners who took part in the study, the Swedish Federation of Forest Owners (LRF), the principle that forest owners (or humankind) must continue to "cultivate" forests, and that we must accept the good with the bad still applies.

> As is asserted in the study's report, all successful cultivation affects the system's communities of organisms, often negatively. This fact is impossible to avoid, but that neither can, nor should, restrain us from continuing cultivation. The critical factor is whether or not the advantages outweigh the disadvantages [109].

For environmentalists, however, there is no doubt that the risks to the environment associated with fertilization would outweigh the benefits it would provide for the climate and the Swedish national economy. As in the 1970s, there is talk that these measures could lead to irrevocable changes in the ecosystem. The idea of decay and humanity's ability to cause harm are brought to the fore. In a statement, the Swedish Species Information Centre says the following on the matter: "For example, it is difficult to recreate a natural heterogeneity somewhere else and soil that has been fertilized makes

conditions unsuitable for many species for the foreseeable future." [116]. The Swedish Society for Nature Conservation (SNF, which, just as in 1978/1979, emphatically rejects the study committee's proposal) believes that the methods advocated would create permanent "ecological deserts" [115].

As is evidenced here, the referral bodies are characterized by serious disagreement with regard to research results. Other statements made by these referral bodies also reveal that a clear struggle exists for control over forested land and the environment. Stakeholders in the forestry sector, and, above all, representatives for forest owners, consider that the proposed methods should be able to be used without the need for a specific permit from authorities, *i.e.*, that intensive cultivation, including fertilization, should be viewed in the same way as current land use. In this way, deregulated forestry is protected and forest owners' power to determine independently how the forest should be managed is safeguarded. These bodies also believe that the general regard for the environment required of conventional forestry could equally apply to areas of intensive cultivation. In this they seek to avoid forest owners being forced to preserve forestland in other areas on environmental grounds [108,109].

The environmental camp and other critics maintain instead that all methods discussed in the report should be subject to a permit. They want society, through public authorities, to have greater control over the activities of forest owners and forestry. The environmental camp, in particular those with an interest in promoting biological diversity, consider it meaningless to apply the rules for general environmental consideration to areas where intensive cultivation is practiced. Instead, these groups demand the preservation of forested land in other areas as a means of compensation [112,116,119,120].

Behind these statements is an underlying conflict as to how the right to private ownership, the common good and public interests are best managed. According to Dryzek these arguments can be related to the conflicting figures of thought as well, *i.e.*, the idea of progress and the idea of decay [22].

To conclude it thus seems like although the argumentation is more complex in 2010 compared to 1978/1979 the same figures of thought continue to influence the debate and to divide parties from each other.

4. Conclusions about the Survival of the Figures of Thought

The purpose of this article has been to investigate both the forestry industry's, and the environmental movement's, attitudes toward forest fertilization over time, as well as to delve into the different "figures of thought" that have manifested themselves in the debate between the two groups. The intention in doing so has been to uncover thought patterns that have stood, and continue to stand, in opposition to one another.

The conclusion drawn from our comparison of the debates on intensified forestry and fertilization of the 1970s and today is that the different groups do not seem to have narrowed the gap between them to any great degree. This is a result that the parties themselves could presumably not have conceived just over a decade ago.

How the situation developed between 1980 and 2010 has not been examined in any depth in this article, although, as earlier research shows, the environmental camp and the forestry industry (and so too, society at large), drew closer to one another during this period, particularly during the 1990s. During the political discourse that research calls "ecological modernization", which rose to prominence as a result of the 1987 Brundtland Commission, stakeholders have worked to unify the

different figures of thought; that is, that economic progress should not rule out environmental awareness, but should work to achieve "sustainable development" that protects the interests of future generations (see e.g., [22,121]).

In a study from the late 1990s, Hellström and Rytilä [61] asserted that the forestry industry and the environmental movement had actually begun to try to include one another in the debate, as opposed to trying to get the better of and exclude one another, as they had done previously. As an example, they point out that forestry companies employed ecologists and educated their employees in environmental issues with the help of representatives from various environmental organizations [61]. In addition, this study shows that, to a certain extent, both groups began to "include" one another as early as the 1960s and 1970s by using arguments and adopting stances on arguments that could be linked to the different figures of thought: the idea of progress, the idea of decay and the idea of a great chain of being. Nevertheless, at their cores, the groups remained ambassadors for their respective figures of thought—the forestry industry for the idea of progress, and the environmental movement for the idea of decay and the idea of a great chain of being.

The comments given on the proposed legislation in 2010 show that at present there is no clear spirit of agreement between the groups: the old figures of thought continue to separate the two. Even if arguments that have their origins in the differing figures of thought are able to move between/be used by all those involved in the debate, the fundamental differences of opinion still remain, in as much as the different parties are forced to defend their respective central ideas. For major forest owners and forest industries, the primary motivating factors are unfailingly production, profitability and growth. This is why they continue to talk about profitability and the common good in their comments on the proposal in 2010, as well as about the fact that the power and freedom to control the forest should belong to the forest owner himself. Business naturally entails a certain degree of risk-taking, both financial and environmental.

For large sections of the environmental camp, the protection and exploration of the ecosystem and biodiversity is the greatest priority. Production and profitability are not motivating factors, even if arguments have been forwarded since the 1970s to the effect that production and profitability will benefit in the long run if forestry adapts its methods to suit the demands of environmentalists. The minimization of risk, on the other hand, is a motivating factor. As such, tolerance of risk-taking is low. Because these are the ideas that constitute the foundations of the two camps, we are prepared to suggest that the differing attitudes towards intensified forestry, including increased fertilization, will continue to remain in the future. Hence, if the use of fertilization continues to increase in the near future (in accordance with Figure 1), it is likely that the public debate about, and critique of forestry, will increase as well, regardless of whether the forests grow faster or not.

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Appendices

Appendix 1. Feedback from referral bodies considering an intensified forestry in 1978/79 [99].

"Yes" to the committee's proposal:	Neither "yes" nor "no"	"No" to the committee's proposal:
Labour market interests:	*Labour market interests*:	*Political parties/alliances*:
AMS (The Swedish Public Employment Agency)	The Swedish Employers Association/Swedish National Federation of Industry	The Centre Party Youth (CUF)
Forestry industry labour unions	The Swedish Confederation for Professional Employees (TCO)	*Environmental conservation:*
Representatives for private forest owners:	Delegationen för glesbygdsfrågor (Rural Development Co)	Nature and Youth Sweden
The Swedish Rural Economy and Agricultural Societies	*Representatives for private forest owners*:	Friends of the Earth Sweden
Skogssällskapet (Forest services provider)	Dalby Norra skogsägareförening u.p.a. (Dalby North Forest Owners' Association Ltd.)	The Swedish Society for Nature Conservation (SNF)
Sveriges häradsallmänningsförbund (the Swedish District Common Lands Association)	The Swedish Federation of Forest Owners (LRF)	*Indigenous interests*:
State-owned forest companies/agencies:	*The Church of Sweden*:	The National Association of Swedish Sami (SSR)
The Swedish Forest Service	The diocesean parsonage board in Strängnäs	*Recreation/health interests*:
The Church of Sweden:	*Industrial interests:*	The Swedish National Health Association
The diocesan parsonage board in Karlstad	Sågverkens råvaruförening (the Sawmills' Raw Materials Association)	*Government agencies*:
The diocesan parsonage board in Luleå	*Recreation/health interests*:	National Swedish Board of Physical Planning and Building (now part of the National Board of Building, Planning and Housing)
Forestry business:	The Swedish Association for Promotion of Outdoor Life	The Swedish Environmental Protection Agency
Foresters' Cooperation Committee	*Research interests*:	*Hunters*:
Research interests:	Statens råd för skogs- och jordbruksforskning (the former Forestry and Agriculture Research Council)	The Swedish Association for Hunting and Wildlife Management
IVA (The Royal Swedish Academy of Engineering Sciences)	*Government agencies*:	*Research interests*:
The Forestry Research Institute of Sweden	The Swedish National Audit Office	Lund University
SLU (the Swedish University of Agricultural Sciences)	The Swedish Agency for Public Management	Umeå University
Government agencies:	*Municipal interests*:	Uppsala University
The Swedish National Board of Agriculture	Svenska kommunförbundet (now part of the Swedish Association of Local Authorities and Regions (SALAR))	*Courts:*
The Swedish Forest Agency	*County councils*:	The Court of Appeal for Southern Norrland
County administrative boards:	Landstingsförbundet (now part of the Swedish Association of Local Authorities and Regions (SALAR))	*The Church of Sweden*:
Jönköping County	*County administrative boards:*	The Administrative Board of the Church of Sweden
Stockholms County	Blekinge County	The diocesan pastorage board, Härnösand
Västmanland County	Gotland County	*County administrative boards:*
	Gävleborg County	Kristianstad County Council
	Göteborg County	Kronoberg County
	Jämtland County	Skaraborg County Council
		Älvsborg County Council
		Södermanland County Council
		Others:
		The Swedish Cooperative Union (KF)
		The Swedish Fortifications Agency

Appendix 1. *Cont.*

"Yes" to the committee's proposal:	**Neither "yes" nor "no"**	**"No" to the committee's proposal:**
	Kalmar County Kopparberg County Malmöhus County Norrbotten County Uppsala County Värmland County Västerbotten County Västernorrland County Örebro County Östergötland County	
Total: 17	Total: 28	Total: 22 **Total: 67**

Appendix 2. Feedback from referral bodies considering an intensified forestry in 2010 [106].

"Yes" to the committee's proposal:	**Neither "yes" nor "no"**	**"No" to the committee's proposal:**
State-owned forest companies/agencies:	*Energy interests:*	*Environmental conservation:*
The National Property Board Sweden	The Swedish Bioenergy Association (Svebio)	The Swedish Society for Nature Conservation (SNF)
Sveaskogs förvaltnings AB	*Research interests:*	The Worldwide Fund for Nature (WWF)
Representatives for private forest owners:	The Forestry Research Institute of Sweden	Friends of the Earth Sweden
The Swedish Federation of Forest Owners (LRF)	*Government agencies:*	*Indigenous interests:*
Forestry business and labour market interests:	The Swedish Civil Contingencies Agency	The Sami Parliament
The Swedish Forest Industries Federation	The Swedish National Financial Management Authority	The National Association of Swedish Sami (SSR)
The Swedish Agency for Economic and Regional Growth	The Swedish Agency for Public Management	*Hunters:*
Research interests:	Statistics Sweden (SCB)	The Swedish Association for Hunting and Wildlife Management
The Royal Swedish Academy of Agriculture and Forestry (KSLA)	The Swedish Board of Agriculture	*Research interests:*
The Swedish Research Council Formas	The Swedish Meteorological and Hydrological Institute (SMHI)	The Swedish Species Information Centre
Stockholm University	*Courts:*	The Swedish Biodiversity Centre (CBM)
Högskolan Dalarna (university)	The Court of Appeal for Southern Norrland	The Swedish Research Council for Biodiversity
Växjö University	The Administrative Court of Appeal in Göteborg	Mid Sweden University
Other government agencies:	*Municipal interests:*	*Government agencies:*
The Swedish Energy Agency	The City of Stockholm	The Swedish Forest Agency
The Swedish National Heritage Board	Eksjö Municipality	*Municipal interests:*
The Swedish Environmental Protection Agency	*County administrative boards:*	Borlänge Municipality
Courts:	Västmanland County	*County administrative boards:*
The Jönköping Administrative Court of Appeal		Kronoberg County
The Court of Appeal for Western Sweden		Skåne County
Municipal interests:		Dalarna County
Ydre Municipality		Västernorrland County
Jönköping Municipality		Norrbotten County
Lindesberg Municipality		
Härjedalen Municipality		
Vilhelmina Municipality		
County administrative boards:		
Sörmland County		
Other:		
Paul Willén		
Total: 22	Total: 13	Total: 17
		Total: 52