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Review

Is It Possible to Compromise Forest Conservation with Forest Use?

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Abstract: A variety of elements in nature, from a pine cone's bracts to a spiral galaxy, are described by a unique mathematical relationship described by Fibonacci as adhering to the "golden ratio". In forest management, various models are used to achieve a balance between forest use and conservation that meets societal expectations in both ecological and economic terms. In Central European countries, where forest management has been subordinated to the timber industry, such a transition is still in progress, and people continue to look for an acceptable balance between forest conservation and management. The main objective of this paper is to review approaches to forest management in Central Europe with the aim of contributing to current discussions on forest management models in Europe. We anticipate that the new EU Biodiversity Strategy for 2030 will implement the billion-tree afforestation program with appropriate consideration of forest potential based on the tenets of sustainable management and that the future climate will be neutral. We hope that the forestry aspects of the strategy will provide a positive impetus to forest management by finding effective compromises between forest conservation and forest use in furthering the aims of sustainable development.

Keywords: forest; conservation; protection; equilibrium; growth; models

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1. Introduction

In the age of modern science, where everything seems possible and yet order can suddenly turn into chaos, there nevertheless are factors that take elements of chance out of natural events. Whether an organism's potential lifespan is shorter or longer is genetically predetermined and subject to strong interactions with other organisms and the environment. However, while life has evolved to produce the existing forms of phylo- and ontogenesis and ecological regulation within complex natural systems, the prevailing view is that order in nature has emerged in which individual organs, organisms, and ecosystems function [1–3]. Order is expressed at every functional level—from genes to landscapes. In natural forests, this order provides a balance of ecological functions. It regulates the spatial structure of the forest through functional relationships between its components in a coordinated chain of physiological processes, which even include the predetermined apoptosis and senescence of cells, that altogether produce ecosystem homeostasis [4–7].

In natural environments where we observe signs of order, can we identify, enumerate and use their order to help achieve management objectives? Attempts to identify order in nature have existed for millennia. Euclid long ago described the so-called golden ratio of shapes, expressed by the number Phi ($\varphi = 1.618$), which Leonardo Fibonacci expressed using the eponymous famous number string. We can also point to numerous examples of the golden ratio in nature—from the dimensions of the DNA helix to spiral galaxies. The forests are full of examples of the golden ratio, such as the arrangement of branches on the shoots of trees, the spirals of the bracts of conifer cones, the arrangement of needle primordia in spruce buds, and the spiral formed by an emerging fern frond. These golden ratios are well known for individual organs and organisms—but can they be found more generally throughout forests, especially in harvested forests managed using more natural approaches? Forest management over the last two centuries has not discovered such relationships. Nevertheless, society is in need of a "golden" compromise that reconciles sustainability and the protection of forests with their commercial use.

Bobiec, Jaroszewicz, and Grzywacz [8–10] considered forests to be rich ecological systems, providing critical habitats for biodiversity, within which there is an orderly sequence of phenomena and processes taking place, specific to the particular environment. Primeval forests, subject only to natural processes or that are inaccessible to humans, such as the Siberian taiga, some alpine mountain forests, or parts of the Amazon rainforest [11–15], are characterized by species compositions adapted to particular climates, soil, and moisture regimes. In these types of forests (regardless of limited human pressure and pollution), the natural relationships between different components of the ecosystem are preserved. Forest formation processes occur naturally in such conditions and forest development takes place according to the species and abiotic conditions of the stand, with competition among trees as they struggle for water, nutrients, space, and light. As a result, nutrients are redistributed from dead trees to germinating coniferous and deciduous seedlings and other plants and fungi, and from them to forest fauna. These processes occur both above ground and within the soil. Trees reach maturity and eventually yield to generational change and forest succession, with life and death intertwining regardless of geographic location, season, or climate [16–18]. Such events lead to the richness of natural forests, with scientific studies on this topic numbering in the tens of thousands. The extent to which natural levels and types of richness are present in managed forests is a potential indicator of the extent to which forest utilization can be carried out without affecting forest processes.

Changes in forest development are caused in nature by various kinds of disturbances, some of which can alter the genetic characteristics of species. These changes can be described as a type of local chaos resulting from a natural event. Such factors as volcanic eruptions, earthquakes, cosmic rays, hurricanes, fires, and floods can alter the trajectory of forest development and have occurred throughout Earth's history. They cause disruption and provide opportunities for different elements of the environment to develop and so alter biodiversity [19,20].

At some point in prehistoric times, *Homo sapiens* emerged—rational and reasonable creatures. This unique species used natural resources and over millennia developed technology that began to shape the environment in which it lived—including forests [10,19,21,22].

In modern times, various forest policies and forestry models have been implemented in Europe. They have been formulated to mitigate climate change, protect biodiversity, and ensure the use of forest resources today and by future generations. In Europe, we currently see two distinct forest management concepts: (i) aggregation, which aims for compromise, versus (ii) segregation, which promotes the separation of forests into areas of protection and areas of forest management. This paper contributes to the discussion about models (i.e., approaches) that affect the impacts of forest management on the economic, protective, social, and ecological services provided by forests. Our aim is to reflect on the theories and models used so far in forestry and to participate in a lively discussion of the approach to forest management advocated by the EU 2030 Biodiversity Strategy, which may currently prevail in Europe. It is expected that the EU Biodiversity Strategy for 2030 will implement the 3 billion-tree afforestation program, with the use of forest practices that protect ecological function and apply the principles of sustainable management, contributing to the EU's climate-neutral ambitions. We hope that the forest strategy will not only accomplish its objectives but also advance forest management in sound ways to obtain effective compromises addressing both nature conservation and forest use in future sustainable development.

2. Methods

The search for optimal solutions that maintain "forest balance" between human expectations of ecosystems and industry's demand for wood is not new and has been addressed both in the scientific literature and other media. We used the Google Trends portal to obtain information about queries directed to the Google search engine. Google Trends evaluates anonymous search data and provides access to users' interests in key topics over time. It allows trends in phrases searched to be evaluated relative to the total number of searches in Google's search engine. The popularity of a given keyword is expressed in contractual units, with a maximum value of 100 indicating the highest popularity. Using this service for search queries over the last 40 years globally, we compared the frequency of searches on sustainability and forest protection.

According to articles indexed in Google Scholar, we found 2.27 million entries for "forest sustainability", 1.22 million entries for "forests under economic pressure", and 3.7 million for "maintaining natural forest development". These topics were particularly important in Central European forestry, both during the industrial revolutions of the 19th and early 20th centuries and during the period of reconstruction of many countries after the two world wars.

In this study, special attention was paid to Polish forestry before 1918 (prior to which Poland was partitioned between three other countries with different approaches to forestry) and after 1945, during the socialist planned economy [23]. This paper also refers to less easily available papers published in Polish (with English summaries).

3. The Normal Forest

At certain points in the development of some civilizations, forests became an economic good. The forest was no longer seen simply for its ability to provide shelter, as a source of firewood and timber, or as a larder containing meat, honey, and mushrooms, but as a commodity and a form of capital. During the industrial revolution in the 18th and 19th centuries, wood became an irreplaceable resource—increasing supplies of wood were required to produce glass and iron, to develop new coal mines, for construction, and even to fuel transportation [24,25]. Thus, it is not surprising that valuable trees of many species, including oaks, beeches, maples, spruces, firs, and larches, were extensively harvested in Europe [26–28]. The quality of timber—resulting from the creation of plantation forests, which produced an ongoing supply of logs, together with the gradual capitalization of private forests, transformed natural forests into managed sources of reliable income. This led to spruce monocultures being planted widely across Europe, including on pastures and agricultural land.

The effects of even-aged monoculture forestry in Europe are manifold, including those observed in Poland, as seen in the Silesian and Żywiecki Beskids, in the Jizera Mountains, and in Warmia and Masuria [29,30]. In forestry, the concept of the "normal forest" was introduced in Germany by Cotta, cited by [31], among others, and was further developed by Hundeshagen and Hagen [32,33]. In a normal forest, the managed forest area is divided into uniform, even-aged forest stands, which in theory will reach maturity with a predictable volume of wood over the course of the rotation cycle [34]. The ideal rotation of forest growth and harvesting would be an example of a so-called perfect "golden division" because it would provide both a continuous, constant income and sustainable forest growth [35]. To this day, remnants of the German school of forestry continue to affect tree breeding, silviculture, and economic decision-making in some European countries. This is evident in concepts of rotation length, the sustained yield of timber (harvested over 10- or 20-year periods), and the concepts of growing stock volume, its increment, and the use of the clearcutting system at a predefined felling age [34,36,37].

Some of the unfavorable changes in forest conditions that took place over the past several centuries are the result of the normal forest management approach, which has affected the tree-species composition and age structure of the forest and which are counter to natural forest conditions. These have led to the development of other theories of forest management and new forestry paradigms. Faced with the loss of forest resources, von Carlowitz formulated the principles of sustainable forest management in 1713 [33], which Hartig [38] developed from the perspective of forest resource protection. However, in the 18th century, deforestation was occurring in some areas and many aspects of traditional forest management became obsolete as "close to nature forestry" approaches developed [32,39–43].

4. Rent as an Equilibrium Point

Although it is difficult to precisely date the appearance of so-called modern forestry, we assume that it occurred in Europe between the turn of the 18th and 19th centuries. From this point on, forests were considered a limited economic good. This influenced the emergence of the concepts of "forest sustainability" and "sustainable timber production". The "normal forest" was supposed to guarantee a sustained yield of timber (the amount of wood a forest can produce continuously for a given intensity of management). These concepts were primarily intended to apply to a clearcutting silvicultural system (Figure 1). According to Poznański [34], this model of forestry, which is based on the assumption that all stands will survive to cutting age and that each stand will be harvested when reaching maturity (equal to cutting age), was believed to be unrealistic, as we know today. The unsoundness of these assumptions was related to the effects of natural disturbances and financial factors. Another unrealistic assumption was that it is possible to maintain fully stocked stands—that is, that actual stand volumes will match the volumes modeled in yield tables. It was the last of these assumptions that was likely the first to be invalidated. Other assumptions about the "normal forest" were so attractive that, for about 100 years, attempts were made to create forests with a normal age structure using the periodic block system. In addition, a "normal" spatial arrangement of stands was used so that silvicultural measures could be carried out in a given stand at the planned time, including final felling, without damaging adjacent stands.

Figure 1. A clearcutting silvicultural system produces even-aged forest stands (a result of artificial regeneration) of regular shape. A gradation of stand ages from felling at different times is seen, from a mature forest (right) to a recently harvested and planted area, an area of young regenerated trees, and a forest stand approaching canopy closure (left) (photo: Z. Sierota).

If it was possible to implement the theoretical "normal forest", there would be a constant growing stock volume within the forest management unit (a set of stands with the same main objective (mainly wood production) and growing in similar habitat conditions) providing a sustained yield of timber (yield that a forest can produce continuously). Would a normal forest be in "sustainability equilibrium"?

In a normal forest, determining the optimal rotation (the period which elapses between the formation of a forest stand and the time it is finally cut) is not self-evident. An attempt to solve this problem by taking into account economic aspects appeared in the mid-nineteenth century with the concepts of "soil rent" and "forest rent" [36]. In the case of soil rent, maximum profitability was expected to be obtained from the forest as measured by the pure (net) income (rent). The formula for calculating this rent, which was related to the formula for the income value of land, was developed in 1813 by König and further developed by Faustmann in 1849 [44]. The calculation of the income value of the forest was carried out assuming a periodic approach to management, marked by each felling of the stand. When calculating the optimal cutting age, it was necessary to take into account the interest rate. Originally, its value corresponded to the national interest rate. However, the relatively high national interest rate meant that the future income from the forest enterprise would not balance the expenses for its management. In order for soil rent calculations to be meaningful, i.e., to produce a positive income, a lower interest rate, known as the forest interest rate, was used. The intuitive assumption about the (lower) forest interest rate was one of the main factors that challenged determining rotation length based on soil rent. Another argument for not using these assumptions was that the value of the forest crop does not increase following the rules of compound interest.

In the case of forest rent, the aim of forest management is to maximize net income from the property [45]. In calculating the optimal rotation length (i.e., cutting age), the interest rate could be disregarded, since all the elements of income and costs were repeated annually. There was therefore no need to reduce them to a particular point in time in the future (as was the case with land rent). To this day, there is controversy as to which of these concepts is more realistic for use in forestry. The soil rent approach, which was popular for many years, led to a lower cutting age because the shorter the rotation length, the lower the expected cost. Using soil rent to plan harvesting probably did not produce maximum income from the forest, since some assumptions about forest rent were unrealistic. Furthermore, an acceptable cutting age was determined only by means of somewhat complex calculations.

5. Intentional Forest and Other Forest Models

Post-war forestry in Central Europe was dominated by the socialist model of management planning, which was borrowed from concepts developed in the Soviet Union. In such a model, the production of goods and services was either partially or fully regulated by the government. This was done to negate Western European models, which were described as capitalist, and placed forestry on new theoretical and practical foundations. Its main premise was the transformation of private forest ownership almost entirely into public ownership, with the rejection of the concept of profit maximization as the goal of forest management, in favor of attaining the forest that best satisfies the needs of the people and achieves the desired level of forest productivity [46,47]. This model was used for 40 years and therefore had a significant impact on forests and forestry where it was practiced. Among the more noteworthy activities were large-scale tree nurseries, intensive resin extraction, damaging tree felling and stump harvesting, linear felling, summer felling, chemical insect control (including the use of DDT insecticide), and others [48–52].

During the political transformation that accompanied the end of planned, socialist forestry, there was a significant backlog of Polish forests in need of contemporary forestry management, which reflected the different forestry practices prior to regaining independence in 1918 and since 1 May 2004, from obligations arising from joining the European Union [8,53–55].

One attempt to correct certain erroneous assumptions of the normal forest has been the creation of an "intentional forest model" (in German literature, known as "der Zielwald" [34,56–58]. The intentional forest can be used, among other things, to account for the following factors: (i) final harvesting will not provide the expected yield unless the forest has the area and structure needed to provide the target yield; (ii) achieving and maintaining a uniform age class structure and spatial arrangement is impossible because stochastic factors influence the forest and, therefore, some stands must be cut before reaching the planned cutting age; (iii) the probability of stands transitioning from a lower to a higher age class is limited by stochastic events (rather than economic objectives). In summarizing these factors and others not listed here, it was also assumed that: (a) the forest has a self-regulating capacity to achieve certain target states, and (b) the maximum target state can be achieved through forest management decisions and actions.

The development of the first selection forest (der Plenterwald) management plan in Switzerland in 1890 represented a different but parallel approach to previous methods of forest management [59]. In a selection forest, trees to be felled are selected either individually or in small patch cuts, with no large, clear-cut areas. Relatively small (usually 5–15 ha) control units (similar to forest stands) are managed individually. They have a complex but permanent structure (approximately constant volume, increment, and proportion of trees in each size class over time) (Figure 2). The aim of selection forest management is to achieve and maintain an optimal forest structure, which is defined as that in which maximum wood yield (increment) is achieved, and later as the maximum yield expressed in financial terms [60].

Figure 2. A selection forest in the Holy Cross Mountains in Poland (photo: J. Mielcarczyk).

The determination of the optimal structure of the control unit in the selection forest is based on regular inventories (usually carried out every ten years). Thus, one needs data on the volume of felled trees, periodic stand volume increment, and the volume of ingrowth—i.e., trees that have grown up to the size threshold (diameter at breast height (dbh) = 17.5 cm in the first selection forests) and grown into the smallest diameter class (dbh = 17.5 cm) within a given period. "Maintenance of Optimal Structure" [61–64] means maintaining a control unit (selection forest) in a condition where:

– The growing stock volume is constant;
– The proportion of volume in each tree size class is unchanged over time;
– Periodic wood volume or wood product value increment is equal (and maximal).

One approach for obtaining an optimal structure in a selection forest is to use a static model of the number of trees in dbh classes, e.g., following the Liocourt–Meyer curve [65,66]. A better solution is determining the number of trees in dbh classes using the "equilibrium curve". In constructing the equilibrium curve, it is assumed that the number of trees in a given dbh class remains unchanged if, in a given period of time, the number of trees that died or were felled and the number of trees growing into the next dbh class from that class is equal to the number of trees that died or grew into the next dbh class from the larger dbh class (Borel after Schütz) [67]. Constructing such a curve requires data on the survival (or mortality) rate of trees and their diameter increment in each dbh class and, to calibrate the curve, the maximum dbh [67,68]. Similar assumptions have been made in natural forest modeling [61,64,69].

So, does a selection forest with an optimal structure display the characteristics of a forest in an equilibrium condition?

6. Real Forest

Foresters managing selection forests have been reluctant to select trees for felling to force the forest to conform to the modeled diameter structure. It was pointed out that diameter structure is not a goal, but rather the result of selection forest management. This is in line with the concept of the "real forest" [34]. Such a managed forest has few internal regulators (i.e., low homeostatic capacity) and is an unstable system. Moreover, the natural and economic environments have long-term effects on forest structure, and forest regeneration depends more on external factors (regulated by the forest manager) than on the structure of the forest itself (Figure 3).

Figure 3. Naturally regenerated tree seedlings in the understory of an even-aged stand (photo: Z. Sierota).

Examples of destructive environmental influences are "fir dieback", "forest dieback", or "forest decline", which occurred in the 1970s and 1980s. Forest dieback in the twentieth century resulted in entire stands and large forest areas, especially in Central Europe, undergoing tree dieback and death triggered by toxic industrial emissions and weather anomalies [70–73]. Examples are forest dieback in the Black Forest (Germany), the Ore Mountains in the Czech Republic, and the Izera Mountains in Poland [74–77]. Only a change in the political system, along with a political paradigm shift, restrictions on industrial emissions, and the growing recognition of the need for an ecologically conscious lifestyle reversed the damage and allowed for the structural restoration of the forests.

Wood from trees that are dead both from natural and human-induced causes (Figure 4) has important ecosystem functions and a direct influence on both biodiversity and forest management [17]. Deadwood in a managed stand has both financial and ecological value. From an economic and commodity perspective, it is undoubtedly of financial value and could be considered lost potential revenue if left in the forest, while the ecological functions of deadwood, including effects on biodiversity, nutrient cycling, carbon storage, soil processes, and microclimate regulation, are increasingly valued [78]. Wood remaining in the forest consists of stumps, thinning and logging residues, and down and standing dead trees. The more deadwood left in the forest, the less that is available for use in wood processing. Ecologically, some microorganisms require large quantities of deadwood [79–83], which, if left in the forest, are not available for use as wood products. Leaving deadwood in the forest could be challenged by forest owners due to its financial value [84,85]. Given the low profitability of forestry, it seems unrealistic to leave even 10% of the felled (or dead) trees for ecological purposes. This means that if more wood from dead trees is to be left in the forest, property owners may expect compensation for it.

Figure 4. Deadwood in an upland mixed fir–beech forest (photo: S. Miścicki).

7. Multifunctional Forest

"Multifunctional forests" have been proposed as an approach to achieve more than just wood production. However, do forests exist where this is practical, and what does multifunctional forest management entail? In Poland, the criterion of technical (commodity) maturity has been used to determine the felling age of trees since the 1970s [86]. The typical felling age for pine stands in Poland is 110 years, although, in practice, the felling of such stands happens from 80 to 140 years old. For some other species, the cutting age can be lower and its range quite narrow—for example, for aspen, the cutting age may be at 40–50 years, while in the case of oak it may be more than 200 years [87]. The optimal cutting age based on stand carbon storage has also been analyzed [88].

The anthropocentric implications associated with specifying a rotation age are obvious. The maximum life expectancy of a stand is shorter than that of individual trees because stands begin to lose their structure when they enter a period of high self-thinning. The life expectancy of trees of a given species is highly diverse. Stands are more likely to be felled in their middle age than when they reach their prime. This is because the highest mean annual increment is achieved while stand productivity and the income earned per year of production are still high [36].

When clearcutting is used in a forest management unit, different characteristics are considered to decide when to cut than in a selection forest management unit or a protection forest. In a clearcutting management unit, as well as in a shelterwood cutting management unit (Figure 5), cutting may take place before stands reach an age at which the volume of trees that die during a given period exceeds the volume growth in the remaining live trees. Cutting may also take place at the age when the value of wood on the logs is greatest, which is usually older than the age when the stand's wood volume increment equals the stand volume lost due to mortality because the wood quality of larger-diameter trees can make the trees suitable for more valuable wood products. Cutting may also take place when stand productivity is greatest, measured either in terms of wood volume increment per unit of time or in monetary terms. A stand's monetary productivity depends partly on market conditions (e.g., the ratio of the prices of different wood products, such as pulpwood versus lumber). In general, cutting ages determined according to wood volume increment and monetary value differ.

Figure 5. A forest managed using the shelterwood cutting system, showing the natural regeneration of different tree species under the overstory layer (photo: Z. Sierota).

Although an age of 100 years has been adopted in some scientific and media circles as a benchmark beyond which trees should not be cut in Poland, this lacks biological and technical foundations. An age of 100 years appeared in connection with the Białowieża Forest to indicate that stands older than 100 years were of natural origin and dated from before the First World War [89–91]. Soon after, it was broadly asserted that any trees older than 100 years should not be cut down. The 100-year benchmark, after which cutting should not be allowed, persists to this day, including for some managed forests, even though this premise can contradict the best practices of forestry as determined by the government and by local forest managers [92–94].

Multifunctional forestry can create a management dilemma if economic objectives conflict with other benefits the forest can provide, especially if financial loss outweighs the value gained from natural processes (e.g., oxygen production, CO_2 sequestration), ecological functions (growth and mortality), and economic factors (income and expenditures) [84,95–97]. A multifunctional forest is one that simultaneously fulfills economic objectives while also providing various protective functions (they can be specific, e.g., soil protection, but also general, such as the protection of species habitats) or social functions (e.g., recreation). However, each forest area is unique, on the one hand in the types of uses that are desired from it and, on the other hand, in the ability of the forest to fulfill those expectations.

8. Forest of Social Expectations

Achieving the goal of biodiversity conservation in forests that are managed for timber production can be difficult. When the main objective for a forest has been wood production, especially in forest stands or even in plantations, it is not surprising that differences of opinion will exist concerning changing the focus of management to species protection. This can be especially true when the issue of protection arises suddenly. An example of this conflict is the criticisms made of monoculture plantations on former agricultural land. In the previous century, stands of pioneer tree species (e.g., birch, pine, and larch) were established to reforest agricultural land as a forecrop, the main purpose of which was to accelerate the creation of forest habitats that will eventually include more shade-tolerant tree species [98,99]. Today, coniferous monocultures continue to be used as forecrops, with all the baggage of the negative impacts they carry [8]. Planting monocultures of coniferous species, which are particularly susceptible to root rot fungi, allows only minor increases in the diversity of trees, insects, fungi and birds, etc. Furthermore, monoculture plantations are usually established by artificial regeneration, which is fraught with numerous difficulties [100,101].

The protection of individual elements of nature has been carried out in managed forests in many countries for many years, but in Poland, it was practiced in state forests only after independence was obtained in 1918 [102,103]. The famous contemporary nature reserve encompassing the primeval forest of Białowieża National Park was protected as early as the 15th century, although not as a nature reserve but as a game reserve for royal hunting [90]. The most valuable natural parts of forest landscapes and nature reserves have been protected by law previously, but the need to protect biodiversity on a large scale was made clear by the conclusions of the Convention on Biological Diversity (Rio de Janeiro 1995–2002) and the documents of the Ministerial Conferences on the Protection of Forests in Europe [38,104]. Legal bases for nature conservation can be found in several European conventions—Ramsar 1971, Bonn 1979, and Bern 1982—and in the directives of the European protected areas network, known as "Natura 2000" [105–110]. The latter, including Directives 1992/43/EEC and 2009/147/EEC for Special Protection Areas for birds (SPI), habitats (SAC), and Sites of Community Importance (SCI), aim to conserve natural areas that are threatened by global change and local pressures [111,112].

It is difficult to balance timber production with the protection of trees. Multifunctional forestry tries to remedy this, but is it effective [113,114]? There is also the question of the scope of protection—should it apply to individual stands, forest districts, or perhaps to a large complex of forest areas? There are impediments to declaring large forest areas as national parks to protect natural environments. Protecting large forest areas is especially difficult for small countries because there are historical and cultural expectations by people in communities that forests will provide employment and other benefits that may be incompatible with protection [115,116]. So, how can we protect natural diversity in forests without depriving society of the valuable products and services forests also provide? Will effective public education communicating the importance of conservation in the face of climate change be sufficient to convince people of the need to preserve natural resources for the present and for future generations [117–119]? These questions are embodied in the forest principle stated by Hartig in 1804, that "...our descendants can obtain at least as much gain from them as today's generation does" (translation after Spindler [120]), which became the guiding principle of the 1987 Brundtland Commission, two hundred years later [121].

9. Final Remarks

The debate on aligning forestry objectives with societal and economic expectations has been ongoing for many years and is summarized in the international conference "Quo vadis forestry" [122]. Regardless of the commonly accepted assumptions related to biodiversity conservation, forest sustainability, or the need to adapt to climate change, forestry has a different character depending on the natural, ownership, and economic conditions on the ground. In discussions about setting objectives for forests, the issue of a clearer division of management and the natural functions of forests is often raised in terms of meeting the needs of nature, society, and industry. The goals for forests, formulated by different scientific communities, forestry practitioners, or non-governmental organizations, do not always account for economic realities and deal very fundamentally with the "forest-human" system, in which the forest, as our common good, should stand above political and socio-economic divisions.

Societal expectations of forests are diverse in time, form, and space. Protecting forests and preserving their natural functions are commonly expressed consensus strategies for climate change mitigation and to protect forests from its harmful effects. At the same time, society wants natural, wood-based forest products and considers them more ecologically friendly than those made of plastic or metal. The extinction of plant, animal, and fungal species is increasing and the need to preserve them is understood, and at the same time, the public does not notice that forestry in many countries is expanding, discovering new species thanks to modern identification methods and finding new ways to preserve species in situ and ex situ. Public opinion is often affected by information campaigns, often of a political nature. However, scientific understanding should be used in unbiased ways, separate from partisan interference and miscommunication.

Worldwide social interest in two aspects of forests by the media, scientists, and ordinary people, since 2004, shows different trajectories (Figure 6). There were similar levels of interest in the keywords "Forest Sustainability" and "Forest Protection" before about 2009, with the lowest interest in either topic during 2010–2012. However, interest in protection has increased in recent years to about twice the interest in forest sustainability, so the latter is beginning to be of interest again, and interest could be enhanced by societal discussion, non-governmental organizations, scientists, and local governments about the future role of forests in climate change mitigation, heat balance, or biodiversity conservation. Forests in general have been gaining public attention, which may reflect interest stemming from societal discussions on the future roles of forests in climate change mitigation, heat balance, and biodiversity conservation.

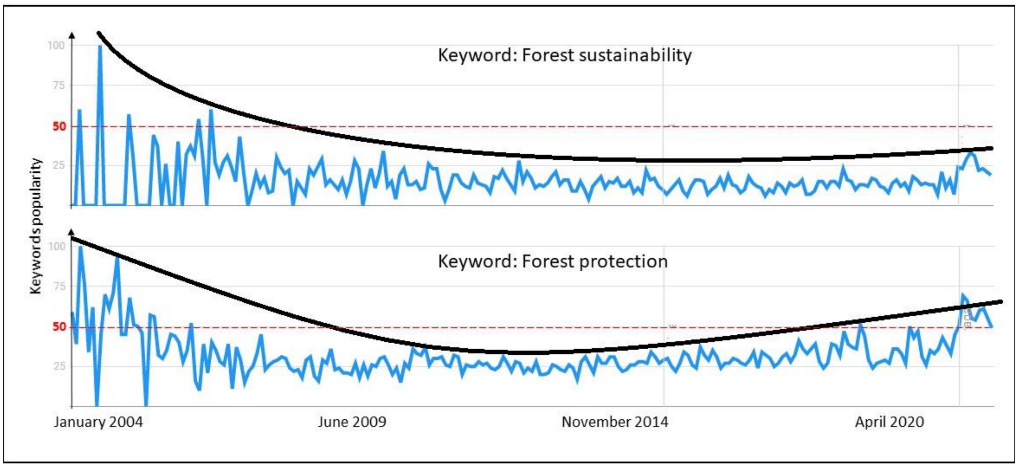

Figure 6. Trends in social interest concerning forest protection and sustainability since 2004, indicated by Google Trends.

Clearly, some forests should be completely excluded from management and treated as national protection forests where biological processes can occur undisturbed and where modern approaches to conservation can be practiced. Forests defined as "protective" (from water, soil, wind, erosion, climate, recreation, aesthetics, etc.) should be partially excluded from management for wood production, and tree removal should serve to maintain the health of forests and forest processes. The existing directives (e.g., for birds, habitats) do not exclude economic activities from Natura 2000 sites, as long as they do not interfere with the implementation of the established conservation objectives for those sites. On the other hand, the remaining areas of forests should be managed for highly efficient timber production based on genetics and selective breeding as compensation for the lost benefits resulting from the reduction in forest areas managed for wood production. Intensive nursery production, the active and targeted use of pesticides, shorter harvesting cycles, and clear-cutting should be allowed where appropriate. The concepts of disease and threat should be considered and managed in terms of anthropocentric and economic values. The need for the spatially balanced separation of economic activities from non-economic functions of forests has been raised several times in Poland [38,43,54,90,123]. This concept is seen as the opposite of the multifunctional forest model (which has been implemented for several decades). Opponents of this concept [124] point out that there are no criteria to determine how large the area of forests managed for intensive production should be and what should be done with forests managed for wood production when demand changes. Society expects a balance between the use of forests to produce wood as a raw material and more environmentally focused forest areas. This means that there still are problems for forestry that require the profession to search for management approaches that can better provide society with "forest harmony".

Some recommendations for further action are included in the current EU Forest Strategy for 2030, which is part of the European Green Deal and the EU Biodiversity Strategy for 2030 [125]. This not only states that three billion trees should be planted in the EU by 2030, but also that forest production potential should be fully exploited, sustainable forest management should be strengthened, and forests should not contribute to climate change by being, at worst, climate neutral. The EU Forestry Strategy 2030 addresses many forest functions. It aims to contribute to the EU's goal of reducing greenhouse gas emissions by at least 55 percent by 2030 and becoming carbon neutral by 2050, as well as addressing the EU's commitment to increase carbon sequestration by natural sinks. Promoting the most biodiversity- and climate-friendly forest management practices is to be done in parallel and in synergy with a strong and sustainable forestry and timber-based bioeconomy. However, some aspects of the increasing societal interest in forests are increasing the focus on protecting rather than exploiting public forests in order to protect forest ecosystems.

The future will tell whether these concepts for forests and forest management will provide the intended results and whether we will learn from the mistakes of our predecessors. However, none of the proposed forest management approaches appear to provide the elements of "forest equilibrium" and they, therefore, fail to serve as a metaphor for the golden ratio, which would more harmoniously incorporate elements of both forest conservation and forest use into forest management.

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