

From sustainable wood production to multifunctional forest management – 300 years of applied sustainability in forestry

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***Franz Schmithüsen and Eduardo
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Franz Schmithüsen * and Eduardo Rojas-Briales **

Summary

As an economic activity, forestry has developed a utilization regime for natural renewable resources that can be practiced for extended periods of time. It aims at maintaining a combination of important forest functions through carbon management, biodiversity preservation, soil and water protection, landscape conservation, and social services provision. All these values can be maintained over several generations if the nature and extent of human interventions do not endanger the natural potential of forest ecosystems.

Today's guiding environmental principle of sustainability has its origins in forestry. In 1713 Hannß Carl von Carlowitz published his book *Silvicultura Oeconomica* and explained that the conservation and growing of wood should be undertaken in a continuing, stable and *sustained* utilization. This was a major step in acknowledging that forests could be managed as a non-exhausting renewable natural resource. Since 300 years the German terms sustainable (*nachhaltig*) and sustainability (*Nachhaltigkeit*) have been used for determining the principle of sustainable forest management. The practical significance of the terms has evolved over time yet retained its essential meaning as conceived by von Carlowitz.

The *Nachhaltigkeit* paradigm is the start of professionally driven forestry, which expanded from Central Europe to the rest of the world. Now, 300 years after the first conceptual definition of forest sustainability, it is worthwhile to follow its evolution. The fact that forest management was ahead of other disciplines derives from the differentiation between physical capital and rent, which is virtual but not physical, and from the observation that the use of forests has multiple consequences (externalities) for other human activities and the environment.

This contribution analyses the economic, social and political significance of forests as a result of successive and superimposed cultural processes. It brings to the fore the importance of the forest as a local environment, a renewable resource, a place one can personally identify with, and a representation of a space perceived as natural, or at least close to nature. Based on historical sources showing the evolution of European forestry, our observations start with forests, which are a physical and social environment shaped by man over a long period. We then show the expansion of the principle of *Nachhaltigkeit* in the evolution of sustainable forest management in other regions. Finally, we address the meaning of sustainable forestry in contributing to the overarching goal of sustainable development in using natural renewable resources.

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1. Introduction

Forests are renewable natural resources like soil fertility, water, flora, and fauna. As a multiple natural resource they have a capacity for self-organization, interconnections with other natural resources, an ability to adapt to changing environmental conditions, highly complex ecosystem structures, and functional variation and productivity. Actual and potential uses of forests are determined by economic needs and benefits, social and political demands, and local, regional, and global requirements. Multiple ecosystem interactions exist among flora, fauna, soils, water regimes, and climate. Important aspects are the spatial differentiation of forests, the variety of plants and animals they contain, and their ability to survive and adjust in a changing environment. Utilization of the forest's natural potential gives rise to economic and cultural developments. In turn, human intervention, use, and management have far-reaching and multiple influences on forest composition, vitality, and resilience. Forests can be preserved, used, and managed in many different ways.

For those who cultivate agricultural land or manage pasture or forest, it is obvious that one can produce and consume only as much as the existing resource potential allows. Caring for the soil, water, grasses, and trees and investing in increased productivity are prerequisites for sustainable land management. Careful use and management of the forest are undertaken by those who feel responsible for its condition stretching well into the future. And it is only when landowners, users, and concerned stakeholders acknowledge their land management responsibilities that sustainability in wood production and multiple forest uses can be achieved. Sustainable management presupposes an understanding of how complex ecosystem processes are mutually dependent on each other, and it requires that today's consumers take into account future economic and social needs, environmental benefits, and cultural values. It is precisely where settlement and land uses are at their most intensive that forward-looking economic production processes, social standards and commitments, and political decisions are most needed (Schmithüsen 2008).

Local management customs and regulations aimed at preserving the forest as a local resource are found in Germany at an early period (Mantel 1990: 151–2, 164–5). Common law recorded as early as 1330 mentions the principle that woodcutting in the forest be moderate and carried out without causing devastation. Specific rules were adopted by villages, communal land associations, monasteries, and towns. Measures for regulating use included a ban on felling fruit-bearing trees and species that yielded other foods and non-wood forest products. Forests near settlements were reserved for uses of the local population and were divided into coupes (rotation areas) to be harvested annually, after which these areas were to be protected from grazing until tree regeneration was assured. In medieval France the concept of sustainability appears in the use of the Old French word *soustenir*, “sustained,” a technical term in the Ordonnance de Brunoy, which is the first known French law dealing with the management of waterways and forests. Enacted in 1346 by King Philippe VI, it stipulated, “The owners of waterways and forests will make enquires about and visit all forests and woods and will conduct sales that will allow the aforementioned forests to perpetually sustain themselves in good condition.”

Europe's woodlands and forests were used as a land resource, available and accessible to the local population (Mantel 1990: 89-90; Hasel and Schwarz 2009: 197-213). A typical form of firewood management was coppicing, taking regular cuttings of sprouting hard-wood species like beech and oak. Coppice forests with standards—that is, older trees left uncut—allowed firewood and construction timber to be produced on the same area. Reports from the 14th to the 16th centuries indicate that hardwoods, particularly oak, were regenerated naturally, and that conifers were sown by seed. The competitiveness of wood was influenced by logging and transport costs, the facilities for raft transport on the rivers, and the value of

the end product (Mantel 1990: 209-29; Hasel and Schwarz 2006: 54). A decisive factor for preindustrial wood uses was in what way the forest could be developed and accessed. Resin working, potash production, and charcoal making were activities that could be carried out in remote regions. In contrast, glassworks, saltworks, mines, and metal production required access and costly infrastructure such as forest roads and rafting installations along creeks and rivers in order to ensure regular supply of large quantities of wood. Permanent transport facilities were essential for supplying large quantities of construction timber to the expanding cities and urban craftsmen, factories, and businesses.

The constantly growing demand for wood for early industrial processing led to more and more intensive prospecting for usable forests and to systematic exploitation of newly opened forest stands (Mantel 1990: 209-10). Deciduous and mixed forests declined and the distribution of tree species, such as beech, oak, pine, and fir, was altered. Complete clearance and inadequate regeneration practices had immense effects on the condition of the forest. The reactions of independent observers, campaigns by local inhabitants, and desperate descriptions of cleared areas and overused forests are witnesses to these developments. Large-scale tree felling not only altered the areas exploited but also affected the structure and composition of those forest stands that developed in afforested areas or through natural regeneration. At the beginning of the 18th century, the demand for wood to supply salt works and the mining industry could no longer be met by expansion into previously unused forest areas. The rapid growth in regional and international trade in roundwood and sawnwood led to increased demand and higher wood prices in many parts of Europe. Local efforts to ensure conservation and management of forest resources were not commensurate with the demand for timber and firewood.

2. Von Carlowitz and the move to *Nachhaltigkeit*

In 1713, when he had been appointed head of the Saxon mining administration, Hans Carl von Carlowitz (1645–1714) published *Sylvicultura oeconomica: Anweisung zur wilden Baumzucht* (“Instruction for cultivating wild trees”). In a 400-page folio text he presented his life experience, the results of reading and many international contacts and visits, and his convictions that a new approach to using forests in a sustainable manner had to be taken. A second, augmented edition, with a new section by the editor Julius Bernhard von Rohr, appeared in 1732. The book became a must for state administrators and managers in the mining industry as much as for the new generations of trained foresters. The book can be read without difficulty today, and the content is in many respects as fresh and relevant as it was when it was written.

Von Carlowitz not only elaborated a framework for a modern forestry and wood processing sector. He created the term *Nachhaltigkeit* by referring to the concept of *nachhaltige Nutzung* (“sustainable utilization”) of the forest. He provided a definition for what became in the following decades the basic understanding of forest management (translation by the author):

The greatest art, science, diligence, and institution of these countries will rely on the manner in which such conservation and growing of wood is to be undertaken in order to have a continuing, stable, and sustained utilization, as this is an indispensable cause without which the country in its essence cannot remain.

Thanks to his work, *nachhaltig* (“sustainable”) and *Nachhaltigkeit* (“sustainability”) have been used for describing the fundamental goals and achievements in managing forest resources.

Von Carlowitz knew what he was writing and speaking about. The son of a forester, he was born in the Saxon town of Chemnitz just at the end of the Thirty Years War. He had studied law and public administration in Jena, learned foreign languages, and as a young man spent five years abroad (Grober 2010, 2012). In 1665 he set off on his Grand Tour of Europe. His travels stretched from Sweden to Malta and included lengthy stays for diligent studies in Leyden in the Netherlands, in London, and in Paris. After his return he entered the state service. In 1677, at the age of 32, he became the administrator of mining, and in 1711 he was in charge of mining industry at the court of the Electorate of Saxony. He lived in Freiberg, in the foothills of the Iron Mountains (*Erzgebirge*), known for silver mines.

In his capacity as deputy and later as director of the Saxon mining industry, he was responsible for supplying large quantities of wood to the mining industry, which employed about ten thousand miners at that time. He was directly confronted with the greatest problem of the then-flourishing Saxon mines, lack of wood. The smelting furnaces were devouring enormous quantities of charcoal, firewood, and construction timber. Large areas of forests had been exploited, and the devastated areas left little hope of productivity well into the future. Trees had been cut over for generations, and old-growth had disappeared, without efforts to regenerate the forests. Due to food shortages extensive grazing of cattle, pigs and goats as well as subsistence agriculture contributed to impede natural regeneration and forest recovery. In many cases these agricultural land-use practices left long lasting consequences for forest soil fertility exacerbated by practices like litter gathering

Von Carlowitz criticized strongly the short-term thinking centred on making immediate profits by ruthless exploitation that devastated large forest areas, and the indiscriminate clearing of woodlands for agriculture, which seemed more profitable at the moment. He developed ideas intended to ensure a lasting supply of wood as a permanent economic resource for his state. He suggested measures that are still central to sustainable management today, such as improving the insulation on houses, using energy-efficient smelting furnaces, and improving agricultural land management practices.

Most important was his forcefully argued and simple message that there would be no future timber supplies if the cut-over areas were not replanted systematically. This implied not just comprehensive legal and economic measures undertaken by the state, but even more a complete rethinking of the forestry problem and major efforts to persuade people to plant trees and maintain the forest regrowth. It also required establishing a technically competent forest service with specialists who understood both the biological basis of tree planting and the managerial tasks of developing a permanent regime of wood production.

Sylvicultura Oeconomica is written in the tradition of mercantilism, which was the prevailing economic theory at his time. It brought a new, rational approach to society and change as well as to man's understanding of nature and his relationship to it in using natural resources. It was conceived in the spirit of the Enlightenment, the Age of Reason that had originated in France—a period that produced the monumental *Encyclopaedia* edited by Denis Diderot (1751–1772) and saw the establishment of learned academies and scientific journals. It was also the beginning of an expanding world of forest sciences and teaching that developed during the 18th and 19th centuries.

The work of von Carlowitz does not stand alone. He was able to learn from others and others came to learn from him. During his life time he developed many professional contacts with scientists, practitioners, and forestry colleagues. Many people visited him and came to learn from his experience. With his extensive knowledge of the literature, he had the ability to compare the forest situation of his own state of Saxony with that of other European countries. And he was well aware of innovative efforts undertaken elsewhere to develop new approaches and a more productive use of land both in agriculture and forestry.

During his five years of travel he had seen the same urgent problems of dwindling forests and increasing demand for wood. During his stay in France he had become familiar with Colbert's legal reforms, which led to the Forestry Code of 1669. He quotes the new code extensively in his book, saying that it contains already most of his own work. He visited the forest of Montello in the Alto Adige, which was managed by the city of Venice for a continuous supply of hardwoods for shipbuilding, for the Venetian fleet. And he likely knew John Evelyn's *Sylva*, a book about forest trees and the propagation of timber, presented to the King, the Royal Society, and the public in 1664 (Grober 2007). Evelyn's book was reissued several times during the 17th century and encouraged the planting of millions of trees to tackle the growing problem of wood scarcity.

Following von Carlowitz, Wilhelm Gottfried Moser, a mercantilist and forester, referred in his 1757 book *Principles of Forest Economics* to the intra- and intergeneration elements of *Nachhaltigkeit*: "A sustainable economy is as reasonable, just and wise as it is certain that man must not live only for himself, but also for others and for posterity." In 1795 Georg-Ludwig Hartig formulated the principle of sustainable forestry in a classic intergenerational perspective, remarking in his textbook *Taxation of Forests* (translation by author), "It is not possible to think and expect sustained forestry if the wood allocation from the forests is not calculated according to sustainability ... Any wise forest direction consequently needs to tax (assess) the woods as high as possible, but aiming at using them in a way that the descendants can draw at least as many advantages as the now-living generation appropriates." In 1841, Carl Heyer referred to the technicality of sustainability of wood production when he remarked that a forest was "managed in a sustainable manner if one takes care of the regeneration of all logged stands in order to maintain the soil that is destined to forest production."

Step by step, policy and law introduced principles of renewable natural resources use. Silvicultural models of wood production were developed adapting wood harvesting to the long-term production capacity of forest stands. The driving forces varied among countries. In Germany, Austria and Switzerland the need to feed the mining and salt production industry were urgent. In coastal countries such as Spain, Portugal, U.K, France, Sweden sustainable wood supply for shipbuilding and the demands of the Marine were among the principal concerns.

The concepts needed to shift to long-term forest management were created from 17th to the 19th century in Germany and the Alpine countries. The Swiss forester Karl Albrecht Kasthofer who had studied in Heidelberg and Göttingen translated the meaning of *Nachhaltigkeit* by "sustained and equal product of a forest". Strong professional relations existed between Germany and France. Bernhard Lorentz, native from Alsace, a life-long-friend of one of the great foresters, Georg Ludwig Hartig, became the founder and first director of the French National Forestry School in Nancy. It was established in 1824, followed immediately by the new French Forestry Code of 1827. The successor of Lorentz was Adolphe Parade, again from Alsace, who had spent several years in Saxony and graduated in 1819 from the Tharandt Academy. He coined the term "production soutenu" in French language.

3. The principle of *Nachhaltigkeit* spreads to Europe and to other continents

Nachhaltigkeit, as presented in von Carlowitz's *Sylvicultura Oeconomica*, became reality in science-based forest research and education (Grober 2007: 22-24). Academies, established for instance, in Germany, France, Spain, Portugal, and Italy became leading research and experiment centres educating the elite of foresters in Europe. The first privately run schools teaching practical forestry courses were founded in the Harz Mountains and Thuringia, followed soon by a school in Tharandt (in Saxony), established in 1811 by Heinrich von Cotta. Forestry professionals and scientists became well known, and technical schools and academies gained reputation and attracted foreign students. Their graduates travelled abroad and spread the idea of sustainable wood production, showing the feasibility of reforestation and sustained yield based on forest inventories and annual utilization rates. Johann Georg von Langen, for example, worked for years as adviser to the Danish court in building up forest resources management in Denmark and Norway, and Tsar Peter I and Tsarina Katharina relied on German experts when establishing forestry in Russia. In fact, the oldest forest education institution that has kept running until present time is the St. Petersburg Forest Academy established in 1803.

Spanish and Portuguese students received grants in order to study forestry in Germany in the middle of the XIX Century and were key for the establishment of the first forest schools and modern forest administrations in their native countries followed by the first forests codes (Spain 1863). In both countries state forests were almost absent and most of the work during the first decades was concentrated in the municipal and communal lands (delimitation, restoration, inventory, forest management planning) while little attention was given to the prevailing private forests (Bauer 1980, Mendez 1999, Rojas-Briales 1992).

The concept and practice of sustainable forestry extended to India through the British Empire. The felling of trees was unregulated, and by 1850 it became apparent that the forest area diminished. In 1850, on the initiative of Hugh Cleghorn, the British Association in Edinburgh formed a committee to study forest destruction. In 1855, Lord Dalhousie, Governor-General of India, issued a memorandum of the Government of India, based on reports submitted by John McClelland, the superintendent of Forests in Burma, calling for forest management.

Dietrich Brandis, a German forester, joined the British service in 1856 as superintendent of the teak forests in eastern Burma. After seven years in Burma, Brandis became inspector general of forests in India and held this position for 20 years. Brandis promoted the "taungya system," an early form of agro-silviculture: villagers provided labour for clearing, planting and weeding teak plantations and in return were allowed to plant food crops for the first years, before the tree cover canopy closed. Because the newly planted areas moved ever farther away from the settlements, the system was difficult for villagers to maintain and led to local resistance and critics (Gadgil and Guha 2006).

Brandis developed teak growth-and-yield tables as a reliable basis for determining annual cutting volumes under a sustainable management regime. Forest protection plans against tree diseases and fire attacks were drawn up, timber purchasing rules formulated, and extensive teak plantation schemes organized and implemented. The Indian forest service, with administrative and operational districts under the responsibility of forest conservators, was established during his time. He prepared new forest legislation and helped establishing research and training institutions—in particular, the Forest College at Dehra Dun. Many of his accomplishments were of interest in other countries in Asia and Africa and contributed to the introduction of sustainable forestry practices.

Dietrich Brandis had been born in Bonn, Germany, and studied at the universities of Copenhagen, Göttingen, Nancy, and Bonn, where he became a lecturer in botany. His interest in forest management thus came originally from his botanical studies. After leaving his position as chief of the Indian forest service, he became involved in promoting forestry education in England and influenced the thinking of Gifford Pinchot and Henry Graves, the first and second chiefs of the Forest Service in the United States. Brandis maintained his lifelong interest in botany and continued research work on Indian forestry. At the age of 75 he started to work on his principal book in forest botany, *Indian Trees*. It was first published in 1906 and reissued several times.

William Schlich, another German forester educated in Giessen, became in 1881 the successor of Brandis as inspector general in the Indian forest service. Later he became the founder of the forestry school in Cooper's Hill and in 1905 he was elected the first professor of forest sciences at Oxford.

The concept of *Nachhaltigkeit* reached the United States through several channels. The first was Bernhard Fernow (1851–1923), who studied at the University of Königsberg and the Forest Academy in Hann.-Münden. Having met a young American woman touring Germany, he travelled with her back to United States and married her. As the third chief of the Division of Forestry in the U.S. Department of Agriculture, from 1886 to 1898, Fernow focused on establishing a national forest system, introducing science-based forest management, and protecting forested watersheds. From 1898 to 1903 he was the first dean of the New York State College of Forestry at Cornell. In 1907 he became the founding Dean of the University of Toronto's Faculty of Forestry. He established the *Forest Quarterly* (which later became the *Journal of Forestry*) at Cornell in 1902 and was the publication's editor-in-chief until his death in 1923.

Scientific and professional ties between the United States and Europe were strengthened during the career of Gifford Pinchot (1865–1946). After graduating from Yale University, he followed the advice of Dietrich Brandis, at that time professor in Bonn, and enrolled in November 1889 in a one-year forestry course for senior officials specializing in forest management at the French National Forestry School in Nancy, France. He used his time in Europe to become familiar with the work of high-level scientists and researchers, both personally and from reading the literature. And he learned much from experienced forest practitioners—for instance, by spending some time in the Sihlwald of the City of Zurich in Switzerland with the forest conservator Meister. He participated extensively in forest excursions in both France and Germany. In his later career he returned several times to visit scientists and colleagues he had met during his stay in Nancy. In 1898 Pinchot succeeded Fernow as head of the Division of Forestry. In 1905 he was appointed chief of the newly established Forest Service, for which he was in charge until 1910. In his later career he was twice elected governor of Pennsylvania.

In the United States during the 1890s, forests were still considered inexhaustible, a bank with endless reserves on which the nation could draw, but this valuable natural resource was running out, and the political and legal institutions to ensure a permanent forest estate had yet to be established. Forest fires had caused extensive, devastating burns, and a rational approach to fire fighting, based on regular observation, monitoring, and large-scale interventions, did not exist. One solution was the creation of large areas of national parks and national forests, but that would not be sufficient to ensure a supply of wood for generation after generation. And Pinchot understood that the American people could not be convinced mainly by state intervention, as was the case in many European countries at that time. To engage in planting trees as an economic venture, Americans needed clear and convincing demonstrations, based on proven and successful experiences, that sustainable forest management by private

landowners would repay the cost and generate income not only in a distant future but in the short term, too.

Pinchot's comments after his return from Europe show that he had learned how sustainable forestry could be accomplished from a technical and silvicultural point of view. But he also understood that the system on which European *Nachhaltigkeit* was based was not the way to proceed in the United States. Europe, at that time, was still a continent with a long history of governmental intervention and control in the forestry sector. It was a continent in which people, at least regarding use and management of state and communal forests, had little to say. Decision making was left to an admittedly competent and dedicated state forest administration. Pinchot had noticed during his stay abroad that the Sihlwald of Zurich was an exception, one of the few examples of *Nachhaltigkeit* in which local people had a say and where forestry developed under democratic decision making in a federal political system. The United States, with its fully developed democratic political system, would not achieve a shift to sustainable forestry without the consent and active participation of its citizens. A comprehensive policy of natural resources conservation and preservation required the understanding and support of the American public, of private landowners, and of policymakers at all levels of government.

On August 1, 1946, two months before his death, Gifford Pinchot completed his book *Breaking New Ground*, which appeared posthumously in 1947 (Pinchot 1947). It is a breathtaking text. For both Americans and people outside United States, the book is a rich source for understanding the state of forests at the end of the 19th century. It gives insights into the origins of sustainable forestry under the constitutional, democratic conditions of the United States. Pinchot was able to combine his knowledge of forestry with a profound understanding of the political, economic, and social circumstances determining the development of sustainability in his country. This first-rate forest policy book remains worthwhile reading today because it addresses so many fundamental issues of fostering forestry development in modern societies.

The work of von Carlowitz in the early 18th century and the two examples from India and the United States in the second half of the 19th century show that it took strong personalities and dedicated professionals to bring together science and practical experience. The three cases show as well that without a profound political change, prompted by problems that threaten a country's future, fundamental changes in man's relations to forests are not possible. In the case of Germany and France, it was the sheer hunger for wood and the fear of how the coming generations could survive without it. The Indian case shows a colonial system driven by rising wood demands in England and the rising and anticipated loss of highly valuable wood resources in Burma and India. The solutions arose from a new understanding of sustainability in the forest sector, a transfer of scientific knowledge, and an innovation in an agro-silvicultural system adapted to local conditions. In the United States, the expansion of sustained forestry resulted from citizens' growing concerns about the dwindling of the national forest cover, the enormous waste of natural resources, the loss of beautiful and unique trees and old-growth forests, as well as from the urgent need to preserve biodiversity and rare or unique ecosystems and landscapes.

4. Building a European multifunctional forest sector

The process of building a productive forestry sector in Europe during the 19th and 20th centuries remains an exciting example and a model for promoting sustainable renewable resources management in other branches of the economy. The decisive aspect during the transition from local management regulations to the implementation of the *Nachhaltigkeit* principle in forestry was the recognition that forests could be used permanently as a renewable resource for profitable and efficient commercial and industrial activities while maintaining and even increasing the productive capacity of the forest. Since the beginning of the 19th century, growing stocks and annual increment have been constantly increasing, thanks to highly developed silvicultural practices. Compared with the previous situation, considerably larger volumes of roundwood can now be used annually in a sustainable fashion.

The separation of agricultural and forestry production systems occurred mainly during the 19th century. It resulted from the efforts of agricultural reformers, begun during the Enlightenment, as early as the eighteenth century, to achieve higher yields in agricultural production by intensifying the management of arable land and pasture. Similar approaches were encouraged to limit damage to forest stands and establish the conditions for increased wood production. Many biotopes with rich biodiversity that had developed under less intensive land management systems disappeared or were reduced in size. Overall, the separation of arable land, pasture, and forest led to important landscape changes. In some regions, particularly in the Alps and the Pyrenees, extensive areas remain in which pasture and open woodland mingle.

By the middle of the 19th century, sustainability of wood production had become a major consideration for foresters, both public and private, who calculated the annual wood harvest quantities in relationship to the yield capacity of the available forest stands. This presupposed regular estimates of the annual tree species increment, inventories of standing volumes of the growing stock, usually at intervals of 10 years (or of 20 years in mountain forests), analysis of soil fertility, and determination of tree species composition and age structure of forest stands. It required adequate and regular measures to ensure replanting or natural forest regeneration, tending and thinning to improve tree and stand quality, and forest protection against fire and tree deceases.

Methods for regulating the rate of annual wood cutting included an area allotment system (*Flächenfachwerk*) that divided the forest into sections for annual wood harvesting. To balance different ratios of wood supply by area, the volume allotment method (*Massenfachwerk*) was then introduced. In this method, the usable total growing stock was divided according to the planned rotation period. More modern methods have included management regulations, based on the annual increment of forest stands, and the control method, in which the sustainability adjustment is based on a periodic comparison of the development of the wood growing stock.

The use of mineral coal by the mid-19th century and the use of fossil fuel during the 20th century had major consequences, as did improvements in infrastructure and the intensification of agricultural production based on mechanization and fertilizers. The diminishing pressure on wood as an energy source modified the conditions under which forests could be used as a lasting supply base for industrial wood processing. This was a decisive element in the passage from locally regulated logging to a modern forestry sector. Putting the principle into practice meant adjusting the intensity of felling to the long-term production potential of forest stands and sites. Silvicultural techniques to ensure regeneration by plantation or sowing, natural regeneration, tending and thinning of young stands, and matching species to site conditions advanced. Forest ecology became an important subject in research and forestry development (Dupuy 2005).

Continuity and increase of wood supply required considerable private and public efforts and investment, but that long-term investment could not be obtained without security of forest tenure. The property rights structure in European forests was largely established during the 19th century. Forestland was surveyed, mapped, and entered in land registries. Defining and clarifying the formal aspects of forest ownership rights, and then marking ownership boundaries on the ground, are probably among the most significant contributions of forest laws adopted during the 19th and the 20th centuries.

The first generation of forest laws tended to restrict or abolish usufruct rights and transform collective tenure into clearly defined private, communal, and state landownership. Customary private and collective use rights were legally registered, or forests still under collective tenure were divided among the users and became private forests. In other cases, communal and state forests were confirmed or newly created. Quite often a combination of private and public forest tenures develop. In the meantime, the distribution of property and use rights has changed substantially, as a result of sales of forestland, afforestation of former agricultural areas, and political and constitutional changes.

In Europe (excluding the Russian Federation), private forests predominate (Schmithüsen and Hirsch 2010). At the national level, there are differences in the origin and current distribution of forestland, as well as in the regulation of use rights. In France, Austria, and the Nordic countries, for instance, most forests are owned by farmers and other private landowners and by industrial companies engaged in the wood-based forest sector. In other countries, the forest is mainly communal property, owned by cities, urban and rural authorities, or other public bodies. This is, for instance, the case in the Swiss Alps and in south-western Europe. In a number of cases, the characteristic form is a mixture of different types of property, with various proportions of forest being in private, corporate, or state ownership. In Central and Eastern Europe, restitution of forest property nationalized before or after the Second World War to its earlier owners has led to extensive changes in forest tenure since 1990 (Bouriaud and Schmithüsen 2005).

Land tenure and forest legislation define the landowner's wood production and management rights in using the forest as a productive asset for generating profit and income. They determine responsibility for maintaining collective uses in the public interest, such as access to forests and protective values in the mountains. Legal requirements focus on protecting forest cover, setting minimum standards for sustainable management, and ensuring increased productivity. New forest laws protect landowners' wood production and right to use their forestland as a productive asset for generating income and profit. They determine landowners' responsibilities for maintaining uses in the public interest, such as public access and protective values in the mountains, by stipulating the maintenance of a permanent forest cover.

In Spain, two main historical events have been of particular importance for the land use and tenure distribution. The first was the *Reconquista* (reconquest of maurish Spain in the middle age) which determined the settlement and land property distribution and its consequences for land development in the pre-industrialization period of the late eighteenth century. The second event was the forced sale of church, municipal and crown forests in the nineteenth century, known as *Desamortizacion*. This process was following the liberal trends of the post French revolution period but was applied in Spain in an exceptional instable political framework affecting at least 4,5 million ha of forests (18% of the forest area). The expected advantages were very limited and many authors identify it as cause of the last deforestation wave of the country (Rojas-Briales 1996).

Another far-reaching and necessary achievement has been the expansion of a legal forest regime. It means that the forest area is protected as a special land-use category. Deforestation

of a parcel of land requires an official permit. Forests cannot be indiscriminately protected, since many forest areas are cleared to accommodate expanding cities, road and railway infrastructure, or agricultural production, but because of such protections, large forest areas have been preserved and today are appreciated as recreational areas, nature reserves, and protected landscapes.

A complementary element has been the growth of a public forest service staffed with forest technicians and professional foresters. Its tasks range from enforcing forest regulations to providing technical and silvicultural advice in forestry planning and management. Another important task is giving advice and technical assistance to private and communal forest owners. Forest technician schools and forest worker training centres now provide qualified managers for both public and private forests.

Forest academies, specialized schools, and forestry research and experimental centres have created a framework for developing the science of forestry. The system expanded considerably during the 20th century when forestry science, research, and education were firmly established in universities. A significant aspect of forest research and education is that it combines natural sciences, technical sciences, and socio-economic science. As early as 1892 the International Union of Forest Experiment Stations (IUFRO) was founded by Austria, Germany, and Switzerland; its first congress took place a year later in Vienna. Soon, IUFRO involved American and European forest research institutes and eventually research institutes from other continents.

Today IUFRO is a worldwide leading research and professional network in forestry and environmental sciences. It brings together more than 15,000 scientists and practitioners in close to 700 member organizations in over 110 countries, promoting global cooperation in forest-related research on the ecological, economic, and social aspects of forests and trees. The network disseminates scientific knowledge to stakeholders and decision makers and promotes sustainable forest policies and forest management practices. In 2000 IUFRO changed its name to International Union of Forest Research Organisations.

Most important in building a multifunctional forest sector has been the work of private and public forest landowners who plant trees over large areas and manage young stands. In the plains and foothills, reforestation and afforestation often have led to plantations of coniferous tree species. Seeding of conifers and large plantations of spruce or pine permitted the rehabilitation of devastated areas where natural regeneration was difficult or impossible to be obtained. Conifers helped landowners to meet economic goals, since thinning of even-aged stands allowed a rapid increase in wood production. In the Alps and other mountainous regions, however, uneven-aged management based on natural regeneration has remained a common practice. Gradually, forest management has evolved toward multiple forms of silvicultural systems combining planting and natural regeneration.

Silviculturists now use a range of harvesting techniques and regeneration methods to achieve a stable and well-balanced condition for production forests. Efforts to promote natural regeneration and the proportion of deciduous trees in planted coniferous stands have intensified. Conservation of the genetic pool, with the aims of protecting biodiversity and landscape features while maintaining the ability of forests to adapt to changing environmental conditions, is now a major silvicultural goal. Close-to-nature forestry practices help maintain the natural diversity of forest stands while providing flexibility in production for the long term and creating attractive, varied landscapes. Naturalness and esthetical values of trees and forests were already acknowledged at the turn from the 19th to the 20ies century (von Salisch 1902).

5. Forest management in the context of sustainable development

What forests mean today to people living in largely urbanized European societies is an interesting subject of debate and social research. The findings confirm, first of all, that forests remain for people a usable and productive part of man's environment, the management of which is conditioned by economic and social preferences and competition with other materials. Because it is a renewable and sustainably managed resource with a largely neutral carbon dioxide life cycle, wood production is today an essential political option in protecting the environment and mitigating climate change.

At the same time, empirical studies show that forests have acquired new meaning in society. For a growing part of the population, the forest represents a space for recreation that is different from intensively used areas. It is more and more identified as a natural environment, perceived by many people to have little human influence. The forest represents the free interplay of natural forces, in contrast with inhabited areas and land intensively exploited by agriculture. This perception reflects the needs and preferences of a growing part of contemporary society and the desire of an urban population for relaxation in natural surroundings. It addresses a need provoked by the impending threats to the environment and the loss of biodiversity, resulting from personal experiences and from the sensitivity toward global-scale phenomena in our world. And for a large number of people, forests represent a place for meditation, reflection, and personal freedom.

The wish to preserve the forest as a symbol of nature find expression in demands for limiting forest exploitation and protecting areas in a condition close to their natural state. Protection of environment and landscape has become a major criterion in judging overall performance in forest management. Surveys confirm that social needs and spiritual values are two reasons why people value green space in and around urban settlements. Forests counterbalance and compensate for effects to which other intensively used areas are subject. In the forest, people enjoy a greater liberty of movement and more spontaneous activities than in urban landscapes. Perceptions and attitudes vary, of course, according to individual preferences and values, economic means and social conditions, but people consider the forest a place where they may walk, engage in sports, study nature, or relax. It is considered as an environment where they can feel happy and recover from daily stress, a place where they can withdraw and express a love of nature, find a quiet place for personal reflection, and enter a realm of physical and emotional sensation. Visitors come to forests for many reasons, but the significance of emotional, spiritual, and mystical values is growing.

Opinions about the role of forests show, for example, that in Switzerland the mountain forest is almost universally considered a natural area that plays an important role in environmental protection (Schmithüsen et al. 2000). To the same extent, it is considered a place for recreation, an element of the landscape, and a renewable resource for wood production. Respondents' answers show that the importance of forests as a natural environment and a local place of freedom determine the priorities they assign to management activities. Silvicultural care and regeneration, as well as repairing damage caused by natural disasters, are considered important or very important by more than 90 percent of respondents. Protection and restoration of flora or fauna receive a similar priority.

As a renewable natural resource with a largely carbon-neutral production and consumption cycle, wood makes important contribution to preventing environmental damage. Compared with fossil energy sources, the use of wood for energy uses has the advantage that the burning process releases only as much carbon dioxide (CO₂) as was accumulated during the prior period of growth. If managers lengthen the rotation period and increase the volume of the growing stock over longer periods of time, more atmospheric CO₂ is sequestered in the form

of wood, making the forest a carbon sink. As a production system based on largely closed energy and material cycles, sustainable wood production needs to be assessed today above all in terms of environmental and renewable resources impacts. The extension and substitution effects of forest areas and the accumulation of stocks of standing wood biomass can mitigate climate change.

Sustainable production of wood was the goal in the time of von Carlowitz. Now, the meaning of sustainable forestry has expanded to include the ability of forest enterprises to produce not just wood and infrastructural services but also many other goods for the benefit of present and future generations. **Sustainable forest management means today** creating the entrepreneurial conditions necessary for a permanent and continually fulfilment of economic and extra-economic needs and goals (Speidel 1984). It addresses the time perspective (permanent and continuing), the kinds of activities (maintaining and creating), the objectives (needs and goals), and the qualifying criteria (optimal fulfilment).

A growing number of interest groups seek to influence forest management, often with conflicting expectations and requirements and with different views on the value of the associated economic and social benefits. For forest owners and inhabitants of rural areas, trade and industry, timber production, financial returns, and jobs are important. At the national level, production performance and competitiveness are decisive factors that determine the development of the wood-based sector. For the population in mountainous regions, forests above all represent protection against the effects of natural dangers (risk reduction) and a potential for tourist development. For the inhabitants of cities, the forests primarily represent open spaces for recreation, leisure activities, and relaxation.

Nachhaltigkeit means now forestry practices that address a range of forest uses, societal values, and management systems. The concept of priority functions allows for a more specific approach by determining which management priorities are assigned to special user interests—for example, at the level of forest stands, operating units, or watersheds. This allows managers to prioritize their objectives and the measures that must be taken to achieve them, and to limit or avoid those uses and interventions that are incompatible with the established land-use priorities. Such a process-steered procedure provides, for instance, transparent evidence of performance in preserving stability and productivity of protected forest areas. Distinguishing priority functions is useful whenever divergent interests lead to conflicting goals in natural resources management. They may relate to entire geographically delimited landscapes and watersheds or to specifically constituted units such as terrain divisions, drainage slopes, forest sites, and biotopes protected under a nature protection law, or to classified areas under a specific land-use regime.

Balancing private and public interests in management planning, seeking agreement among stakeholders with divergent interests in preparing national forest programs, and creating workable arrangements for landowners facing public demands have become important forest policy objectives. These developments are the result of a major shift from governmental and hierarchical regulatory systems to formalized negotiation procedures, public process steering, and joint management responsibilities. Close-to-nature forestry practices allow managers to adapt their strategies to changing societal values. Favouring flexible and long-term production cycles and relying to a considerable extent on natural site factors, they contribute to maintaining biodiversity, varied ecosystems, and diversified landscapes, and leave options for alternative uses and new developments. Acknowledging economic necessities and multiple social and environmental demands, multifunctional and close-to-nature forest management usually offers a range of land-use options for the future.

There is a trend to shift or delegate constitutional responsibility for forestry matters to regional governments. Where the national level remains responsible, regional entities are

becoming more involved in policy implementation. A similar process is occurring between the state level and communities or associations. The transfer of responsibilities favours multilevel political decisions and the negotiation of locally adapted solutions. It acknowledges that forests are both a national concern and local resources in which rural and urban people have immediate interests. Together, these developments and trends have contributed to form a new political framework for forest policy making and bottom-up governance much different from the more top-down, structured system that developed during the 19th and early 20th centuries.

These trends are aligned with those which are reflected as well in Spain since the adoption of the Spanish Constitution in 1978. Growing environmental awareness, regionalisation and decentralisation and increased participation, as well as Europeanization and globalisation are the new factors emerging as key elements of forest policy and legislation (Rojas 2000a, Rojas 2002). Increasingly, EU policies influence on forest conservation and preservation, not only with regard to public incentive instruments, but also in the normative like environmental assessment or Natura 2000 and water or climate change (Rojas-Briales 2000b). National and sub-national forest programs emerged very pre-eminently since the first one was adopted in Andalusia in 1989 for 16 of the 17 Spanish regions and the central government (Glück et al. 2002).

If the conflicts generated by land use were previously at the fore, the very purpose of the forest and how it is managed currently make up an essential part of debates about people's relationship with the environment. The fundamental concepts and management systems can now be found at the centre of political debate. In the face of more and more pressing demands for environmental protection and conservation of biodiversity on a large scale, it is not the principle of sustainable forest management that is in question but certain forestry practices that are deemed incompatible with sustainable development. A land management regime capable of taking into account profound currents of opinion in our society will benefit from the approval and acceptance of the population. Multifunctional forest management can react more flexibly to diverse social interests and adapt to local conditions. It leaves open multiple options to respond to market trends and the changing needs and values of the population while not precluding the options of future generations.

Several forestry terms have been used, each putting a particular emphasis on the meaning of sustainable forestry (Le Master and Schmithüsen 2008).

- *Forest management*: the practical application of biological, physical, quantitative, and qualitative information required for implementing managerial and political principles related to the use and regeneration of forests to meet specified economic goals and social objectives while maintaining the productivity of the resource.
- *Multiple-use, sustained-yield forest management*: a strategy focusing on sustained production of multiple resource outputs as determined by economic demands and social values to best meet the needs of landowners, forest users, and of the public.
- *Sustainable forest management*: the practice of meeting forest resource needs and values of the present without compromising the similar capability of future generations.
- *Sustained-yield management*: managing a forest to achieve and maintain a balance between timber growth, increment, and felling.
- *Forest ecosystem management*: a strategy guided by explicit goals, executed by policies, protocols, and practices and made adaptable by monitoring and research based on the best available understanding of interactions and processes between human

activities and forest ecosystems necessary to sustain the composition, structure, and multiple functions of forests over the long run.

More than a century ago, Europe and the United States approached forest management differently. Europe's degraded forests were replanted and managed for sustained yields of timber under strong forest protection laws and conservation programs launched mainly by public forest services. North America still had vast tracts of untouched timber, and in its democratic capitalist culture, a conservation movement was just beginning to take hold. The underlying assumptions of European sustained-yield wood production did not fit American circumstances at that time. Neither land nor timber was scarce, and whether the demand for wood was stable was at least questionable. Accordingly, appropriate standards for forest management were uncertain. Still, in the late 19th century, wood was the principal construction material and energy source in the United States, and large forest areas were cleared with no thought of reforestation. A growing concern was whether a regional or national timber shortage would limit economic growth. By the end of the 20th century, both continents had embraced multiple-use forestry to meet the complex demands of their societies. Europeans and North Americans are now revisiting forest management because the political and social context has changed (Sample and Anderson 2008).

6. Conclusions

Environmental conditions and cultural development processes determine the spatial distribution of forests and how forest vegetation has been influenced by human activity. This applies to forests that have been exploited for hundreds of years as well as to wooded areas that, to all appearances, have been barely touched by humans. The reasons behind the actual delimitation of the forest and open spaces are manifold. For instance, forests may acquire particularly high value for economic, social, and cultural reasons or, conversely, had minimal economic value in the past. Differences between intensively exploited areas and those showing few apparent human interventions depend on social values and needs, economic potentials, and political regulations. Nevertheless, all forests, including those considered wilderness, are spaces influenced by humankind.

Forestry development takes place in a complex interplay between the potential of today's forest areas and the changing requirements and needs of forest owners, other users and stakeholders, and the public in general. Its dynamic is determined by new economic and technological requirements, multiple landowners' objectives, and by a considerable range of mutually supportive and competing private and public interests. Forests are valued as renewable economic resource for the production of wood and non-wood forest products, as an environmental resource, as a constitutive element of nature and landscape, and as a significant part of our culture and traditions. Forests are a local resource, complementary to agricultural and pastoral uses, and they are the resource base of modern forestry and wood-processing industries. Use and management of the forest potential contribute substantially to economic and social activities, which in return shaped the forest to a large degree. The varied landscapes and the successive forms of forest uses, observed during different historical periods, demonstrate the diversity and intensity of multiple needs and benefits, the importance of spiritual values, and the impact of changing economic, social and political realities.

The principle of sustainable development has become a paradigm of our thinking and a point of reference in understanding the meaning and validity of our actions. Precautionary long-term measures and careful treatment of the natural resources potential are fundamental elements of behaviour and integrative values in our cultures. Production and consumption cannot be separated from responsibility for the consequences. The present economic benefits

of our actions compared with foreseeable aftermath from forest destruction, overuse, and loss of biodiversity cannot be systematically reduced to the yardstick of the present day.

The 1992 United Nations Conference on Environment and Development in Rio launched a process that has culminated in a clear definition of sustainable development. Agenda 21 and the Declaration on Environment and Development adopted at UNCED are landmarks for the international community. They establish the principles of foresight, justice, and balance between divergent interests as indispensable conditions for maintaining a liveable human environment. They are a standard for judging global, national, and local development that meets the needs of present and future generations.

Sustainable forestry practices have steadily developed since von Carlowitz has coined the term *Nachhaltigkeit* in 1713. The central idea, developed and implemented by forest professionals, forestland managers, and forest scientists, has remained the same during the long history of forestry development. But the context in which the goals of sustainable forestry have been formulated and the strategies to achieve them have been continuously adapted to the changing forest environment and socioeconomic conditions of a country. Sustainable forest ecosystem management is now practiced in different forms in all world regions. The lessons of implementation under different and changing socio-economic and cultural conditions in different societies are of great value for maintaining and using the world's forests. At the same time the experiences gained in wood-based forest sector can help other sectors and socio-economic domains by showing how sustainable strategies for using a renewable natural resource can be designed, implemented, and adapted over time.

One lesson is that sustainable management practices can be put into practice only if the strategies are supported by local, regional, and national efforts to protect the potential and resilience of forests, fulfil the needs of both rural and urban dwellers, generate economic value from wood and non-wood forest products, and provide environmental and social benefits. The iron law of locality for making decisions, formulated in forestry as early as the 19th century, cannot be cut short. To maintain the principle of sustainability while employing different strategies to achieve it is the secret for attaining the goal. An effective and efficient combination of private and public sector efforts to determine private uses and benefits while protecting the public values of trees and forests is essential.

Another lesson is the need for understanding varying time scales in practicing different types of multifunctional forestry. For instance, sustainable forestry may start with forests and tree species with long rotation cycles, which allow flexibility in adjusting forest management to changing economic, social, and environmental conditions. Long rotations leave a range of options for choosing new strategies for implementing multifunctional forest policies. Long-term management cycles also contribute to maintaining naturalness and biodiversity, either by using old-growth forests or by extending the production cycles of new plantations. Short rotation cycles based on forest plantations are an alternative approach to introducing a sustainable forest management regime in parts of the world where forestry originated mainly from short-term plantations and is gradually moving toward longer wood production cycles.

It is important to strengthen the interplay between private management activities and public arrangements for setting the conditions to protect the forest cover and foster productive uses in multifunctional development. Strong institutional rules, processes, and instruments for policy and decision making are prerequisites for protecting the capital stock of forest resources and ensuring a balance between private and public needs and demands. Knowing how to engage all stakeholders in forest law and policies setting is indispensable. Short- and long-term monitoring and evaluation processes assessing trade-offs between the benefits of today and those expected in the future are necessary.

The ongoing reduction of the world's forest cover, concentrated at present in tropical and subtropical regions, and its implications for carbon emissions from forest clearings are a major cause of international public concern. Sustainable forestry practices have gained considerable weight in international debates and policy processes and encourage further progress in the preservation of valuable ecosystems. Thus now is an opportune time to recall the origins of *Nachhaltigkeit* and the history of sustainable forestry, beginning with clear goals for wood production and proven silvicultural techniques for regenerating, planting, and managing forests. That one ultimately cannot harvest more wood than the stocking volume plus the annual increment of the forest stand is as true today as it was in the past.

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