They Talk About the *Dauerwald* in Salem, Missouri

By James M. Guldin and Hermann Rodenkirchen

Dr. James Guldin, an expert in the theory and practice of uneven-aged silviculture and continuous cover forestry in the United States, and Dr. Hermann Rodenkirchen, an expert in the practice of close-to-nature forestry with the *Arbeitsgemeinschaft Naturgemäße Waldwirtschaft* (ANW) of Germany,[1] spent a hot afternoon in August 2017 with the staff of the Pioneer Forest in the heart of the Ozark Mountains of southeastern Missouri. The 143,000-acre (58,000 ha) forest is owned by the L-A-D Foundation, which was established by Leo A. Drey, the Missouri forester and conservationist who purchased the property from a number of landowners in the early 1950s; the largest acquisition was 90,000 acres (36,400 ha) bought from National Distillers Products Corp. in 1954. In 2004, Drey and his wife Kay donated Pioneer Forest to the L-A-D Foundation—the largest conservation-based charitable gift in Missouri history.[2] The foundation is continuing the commitment to conservation-based management championed by Drey, the key element of which is the continued reliance on uneven-aged silviculture that has been a hallmark of management on Pioneer Forest since Drey began to acquire the property more than six decades ago.

The two experts carefully examined several stands on a field tour where cut-over upland oak-hickory and oak-pine stands have been managed since 1954 using the uneven-aged selection method. The current mixed-species multi-aged stands feature white oak (*Quercus alba* L.), managed for high-quality and high-value sawtimber, highlighted by veneer logs for woodworking uses and white oak stave logs for tight cooperage barrels used in the production of wine and spirits, especially whiskey manufacturers, in the United States and elsewhere in the world.

Later that evening, inspired by their observations of the day (or perhaps by a sample of the liquid products produced in one of those barrels), the two foresters talked about the development of the awareness of the *Dauerwald* in the United States, the implications for theory and application of the method in ways that would be of interest to European and North American foresters, and how these principles apply to Pioneer Forest (PF). The following is a synopsis of a long and continuing conversation between the two that originated from that late-night discussion in Salem, Missouri.

THE RISE IN AWARENESS OF EUROPEAN FORESTRY IN NORTH AMERICA

Jim Gulden: The earliest forestry experts in the United States were products of a European forestry education. Bernard Fernow, a Prussian who studied at the Royal Prussian Academy of Forestry, emigrated to the United States in 1876 and became head of the Division of Forestry within the U.S. Department of Agriculture in 1886. Gifford Pinchot, who succeeded Fernow in 1898 and converted the Division of Forestry into the U.S. Forest Service in 1905, had spent a year at the French National School of Forestry in Nancy. Schmidt provides an excellent and detailed synthesis of the German influence on American forestry prior to World War II.[3]

However, taking the concepts of European forestry and using them in practical application in forests of the U.S. was the work of Carl Alwin Schenck.[4] Born and educated in Germany,

Schenck arrived in America in 1895 to manage the 125,000-acre (~50,585 ha) forest on George W. Vanderbilt's Biltmore Estate near Asheville, North Carolina. In 1898, Schenck started the Biltmore Forest School, America's first forestry school, to train men to assist him in the woods. Many of the school's more than 300 graduates became influential leaders in both government and industrial forestry.

Hermann Rodenkirchen: We know Schenck discussed the fundamentals of both German and Swiss silviculture, including group and single-tree selection, in his book *Biltmore Lectures on Silviculture*.[5] And Schenck conducted field tours of German, Swiss, and French forests for his American students to show them different examples of sustainable forest management. Schenck disliked German approaches to clearcutting, and other forms of harvest cutting that sacrificed future harvest potential for immediate gain. Instead, he advocated sustained production of large high-value sawtimber (what he and others called "conservative lumbering") and appreciated very much the regulated selection system forestry used in Switzerland, characterized by the periodic "control method," which was developed and practiced since 1889 by Henry Biolley.[6] Interestingly, Schenck later corresponded in 1950 with Karl Dannecker, the first president of ANW, who was a strict proponent of single-tree selection.

JG: Also in 1898, Fernow became Dean of the College of Forestry at Cornell University, and built a curriculum based on German forestry practices.

HR: You must know, Fernow was no friend of uneven-aged forest management. He was a strict advocate of the scientifically based German age-class forestry, developed in the early 19th century.

JG: Well, in 1903 Fernow was fired—for clearcutting the Cornell School Forest to put in white pine! He finished his career as the Dean of the Faculty of Forestry at the University of Toronto in Canada.

However, Fernow's book, *A Brief History of Forestry in Europe, the United States, and Other Countries*,[7] provided U.S. foresters and forestry students with a detailed report on the evolution and current practice of forestry around the world. A third of the book is devoted to the evolution of forestry in Germany.

He reports that in the fifteenth century, harvesting in forests in the region was generally unregulated; in 1488, a low diameter limit of 12 inches (30 cm) was recommended, with restriction of pasturage in regenerating areas.

HR: At that early time, mixed-species deciduous forests in Germany were frequently harvested using the coppice with standards method; coniferous forests, however, were harvested by rough selective fellings. Farmers owning mountainous mixed forests with fir, beech, and spruce used "plentering" (predominant removal of scattered big trees) for centuries, without any method to regulate harvests. By and large, it worked—and a few are still doing it! It's no surprise that farmers often keep their own traditions or their old ways of doing things. But the traditional, unregulated selective plentering harvests were severely criticized by early forestry scientists and state forest administrations, and sometimes also prohibited by law, because landowners using

plentering harvests often paid little attention to regrowth. That's how the expression "plentering is plundering" evolved.

JG: In his book, Fernow noted that early German efforts at the selection method failed because of an inability to obtain regeneration, especially in oaks and pines; the approach had better luck in the tolerant spruces and firs. He reported on early attempts at even-aged regulation in Germany in the 1700s, with the pendulum swinging from selective cutting to thinning and clear–felling. He then introduces us to two fathers of German forestry, Georg Hartig and Heinrich Cotta. Fernow's *Brief History* described how, in 1808, Hartig published eight general rules of natural regeneration in beech forests that set forth principles of the shelterwood method in fairly good detail. But Fernow complained that much "mischief and misconception" resulted from their generalization in other forest types.

HR: But Hartig and Cotta also advocated plantation forestry with spruce or pine monocultures on degraded lands. They developed a sophisticated German clearcutting system that used fixed rotation ages (similar to agriculture), leading to very artificial forest landscapes with geometrically configured, large blocks of pure coniferous plantations.

JG: Fernow reports that a counteraction to those dogmatic rules came from Karl Gayer, professor of silviculture at Munich, and led to a reawakening of interest in natural mixtures and in group fellings associated with the selection method or *femelschlag*.[8]

HR: As far as I know there was also pushback by some landowners, not necessarily the foresters, against the problems of the clearcut system and plantation forestry. Plantations were frequently affected by insect attacks, windthrow, increasing soil degradation, and decline in growth. This resulted in the loss of both wood volume and value, and an interruption in cash flow for landowners. It also incurred high costs for replanting, which was often difficult or unsuccessful because of frost, grazing, and aggressive grasses. Landowners expected a steady flow of profit from the forest, which required stands to have good stocking and vigorous trees across all age classes in the stands being managed. These needs were met more effectively with uneven–aged, mixed species systems.

The main worry for landowners was that a major disturbance would ruin their forests. They saw the solution in a management philosophy that promoted stable and resilient, "close-to-nature" systems with trees of all sizes. Relying on natural regeneration rather than planting was an advantage because it did not require a large financial investment. In short, the goal was to maintain cash flow for the landowner by saving money, and by producing a regular income from a steady supply of high-value timber.

AWARENESS OF THE *DAUERWALD* IN NORTH AMERICA

JG: The *Dauerwaldwirtschaft* papers were published by Alfred Möller in the early 1920s.[9] In all likelihood, foresters in the United States learned of it from a review published by Ralph Hawley in the *Journal of Forestry* in 1922. Hawley was the longtime professor of silviculture at Yale University.[10]

Hawley defined the term *Dauerwald* as "management which maintains continuous forest." He reported that Möller divided the methods of management generally used in the region as either

Dauerwald methods or clearcutting methods, with the shelterwood methods included in Möller's definition of *Dauerwald*.

HR: It is widely accepted nowadays that *Dauerwald* is a general term. It isn't related to a specific current forest structure or a regeneration method, but depends on the intent of the forestland owner to maintain a continuous forest. Stand age and rotation period do not play a role. The emphasis is put on the continuous selection-system tending and harvesting of stands, which automatically leads to the development of a desirable vertical forest structure, or a small group/mosaic structure in case of intolerant tree species (or low site quality). Tending, harvesting, and regeneration take place on the same area and at the same time. Foresters using the *Dauerwald* method must be flexible to adapt the marking method to local stand and site conditions.

The Plenter forest is a specific type of *Dauerwald* that depends on a balanced stand structure created by strict single-tree selection; it is restricted to forest types dominated by very tolerant European silver fir (*Abies alba*), Norway spruce (*Picea abies*), or sometimes also European beech (*Fagus sylvatica)*.

Möller accepted a wide range of structural possibilities about what could be *Dauerwald*, but he emphasized one fundamental characteristic: *Stetigkeit des gesunden Waldwesens*. This means managing the forest to maintain and utilize a healthy and self-regulating ecosystem[11] with nearly balanced, interrelated components: a biologically active and productive soil, a diverse fauna and flora, and an uneven-aged mixed forest with enough standing volume for permanent high-value timber production. These elements are impossible to achieve concurrently in clearcut forestry.

JG: The British silviculturist R. S. Troup covered Möller's work in his 1928 textbook *Silvicultural Systems* as well but I doubt that Troup's textbook was widely available in the U.S. at that time.

HR: Troup was not really convinced of the general merits of Möller`s *Dauerwald* concept.[12] He feared that unfavorable conditions (large areas, no intensive supervision, less successful regeneration) could cause a chaotic breakdown of forest management. Nevertheless, he accepted the fact that this approach appeared to work well at Bärenthoren. I'll discuss that shortly.

JG: Troup wrote that Möller applied the *Dauerwald* term generally to any system not involving clearcutting and exposure of the mineral soil, and would be comfortable including shelterwood methods. But Troup reported that Dr. Dengler of Eberswalde proposed a more detailed grouping that considered the *Dauerwald* ideally as the selection system, separated from the *Femelschlag* systems, the shelterwood systems, and clear-felling.

HR: Dengler was an opponent of Möller`s *Dauerwald*. However, his proposed grouping fits rather well with the *Dauerwald* definition of ANW in Germany.

JG: Hawley and Troup both described the details of the development of the method, as follows: Möller's 1920 paper described the management of a Scots pine (*P. sylvestris* L.) forest over the previous 29 years in the town of Bärenthoren, near Dessau in the German state of Anhalt (today, Saxonia-Anhalt). Troup wrote that the 1,600-acre (650 ha) estate belonged to *Kammerherr* Friedrich von Kalitsch, who was also a trained forester.

HR: Kalitsch was an academically educated forester, landowner, and practitioner, not a forest scientist. He had no money and could not afford planting his forests, so he tried natural regeneration instead. This was a turn away from common practice at the time.

JG: This question of not having much money to invest turns up in the American experience with the selection method as well. Hawley describes four general attributes of the *Dauerwald*:

1) Maintaining forest cover, including uninterrupted tending of the soil and the stand;
2) use of natural regeneration;
3) annual felling of selected individual trees; the tree rather than the stand is the unit of management; and
4) securing the highest possible growth percent on the biggest and most valuable growing stock.

HR: A characteristic of the "plenter principle," applied in *Dauerwald*, is to examine every tree and judge it on its own merits.[13] Even if a tree has a visible defect, the tree is not necessarily expendable (*entbehrlich*). It may have other functions to contribute to the local ecosystem that are important to retain, such as a benefit to species diversity, to soils, to mast production, or to wildlife.

JG: Troup summarizes the ecology of the Kalitsch estate nicely. The forests in which the *Dauerwald* was first implemented were 40-year-old Scots pine (*Pinus sylvestris*) plantations, with natural regeneration of pine occurring abundantly. Terrain was generally level, and the elevation of the area was about 128 m (420 ft). Soils were sandy, and the climate was generally dry; the region receives only about 56 cm (22 inches) of precipitation per year due to the influence of the Harz Mountains to the west.

In his 1922 review, Hawley noted that there were seven features of the *Dauerwald* as practiced at Bärenthoren that were noteworthy, based on Möller's descriptions:

1) There is an absence of clear cuttings; Möller says that clear cutting makes the harvested part of the stand unproductive for timber production.
2) The entire area of the forest is gone over annually, and carefully thinned, including thinning in overstocked pockets of regeneration where trees are cut and left in place; the goal is to have the crown occupy one-third of the height of the tree.
3) The success of the method is due to the interest and technical ability of the landowner, von Kalitsch.
4) Branches and thinnings in young stands remain on the ground, to build up the litter.
5) At the same time, removal of the litter, which prior to 1884 had been a common practice in favor of agriculture, is prohibited.
6) In older stands, pine reproduction is desired, encouraged, and comes in.
7) A fixed rotation age is not considered; each tree is held as long as possible; the greatest growth percent in timber comes from the biggest trees.

HR: Several of these observations require a comment.

For instance, there was a lot of litter raking in former times, which was very bad for soil health. Part of the increase in pine growth and regeneration, Möller reported, may have been because

litter raking was abolished, causing some recovery of soil health, but not yet a competitive dense ground vegetation, only a moss layer.

In *Dauerwald*, regeneration is never promoted by complete overstory removal. Some canopy is always retained. Regeneration comes in automatically due to regular thinning. And gaps are not cut in the forest just to make gaps. But if a small or large pocket of regeneration can benefit, mainly in the case of light demanding, intolerant species, a gap can be created; we call this *Gruppenplenterung* (a kind of group selection). However, immature trees of upper or intermediate layer that could grow into high-value trees are never sacrificed for regeneration! Regeneration is not allowed to drive the system.

One fundamental requirement for natural regeneration in German forests, including *Dauerwald*, is to regulate the deer population. Most German forests do not have natural predators of deer, so hunting deer is extremely important. But the goal of hunting is not to bring home a trophy deer, it is to regulate the number of deer so regeneration can become established and develop properly as an element of functional forests.

Also, the *Dauerwald* needs tree species that are site-adapted and that produce natural regeneration. If a tree species is not adapted to the local site conditions or does not produce natural regeneration, it will not be useful. Tree species that work well in the *Dauerwald* should be competitive, should grow well in volume and value, should not degrade the soil, and should be resistant to stressors such as windthrow, pathogens, and bark beetles. For example, in Europe, non-native Douglas-fir (*Pseudotsuga menziesii*) can be managed using the *Dauerwald* approach with group selection on a wide range of acid soils. But eastern white pine (*Pinus strobus*) in Europe is not a good species for the method, because it is highly susceptible to mortality from blister rust.

In the *Dauerwald* method, we know that the value of a log, depending on its quality and volume, shows a logistic growth with time and as stem diameter increases. The optimum diameter for harvesting a crop tree is the point just before the value reaches a maximum [value?], and when the current growth in value starts to decline significantly. If a large tree develops rot or discoloration, it will lose value even though it may still be increasing in diameter.

JG: In the 1922 review paper, Hawley goes on to describe some of the debate that Möller's 1920 paper inspired. Many of the comments centered on three issues: the effect on soils, obtaining regeneration, and the frequency of thinning. One expert spoke to the contradiction between the heavy litter layer promoted by the method, when exposure of mineral soil is needed to obtain pine regeneration. Another critic suggested that a key to the method was maintaining soil fertility.

HR: Soil fertility, mainly nitrogen availability, was certainly improved in Bärenthoren by prevention of litter raking and slash removal respectively. But Möller was blamed by the soil scientist Walter Wittich, who pointed out that natural pine regeneration is restricted to specific soil and site conditions regardless of whether the *Dauerwald* was being used or not. Möller said the *Dauerwald* only works when soils are in good condition. And Wittich forgot to mention that traditional clearcut forestry using large single-species pine plantings never cared much for obvious site differences and soil fertility. Of course, today we have detailed maps that describe

soil and site conditions and inform about the potential for natural regeneration of pine versus hardwoods. These maps were still unknown in Möller's time; and Kalitsch's decision to rely on and work with natural regeneration was an innovative, courageous approach at this time!

JG: Another expert suggested that the *Dauerwald* stands were not necessarily mature enough to regenerate. Some experts, but not all, had concerns that the logging activity might affect the regeneration. Another suggested that the principles of the *Dauerwald* were common to both the selection method and to modifications of the shelterwood method verging on selection, views that Möller probably held. Several experts agreed that a three-to-five year cutting cycle was more practical than annual harvests, with which Möller agreed.

HR: Möller claimed that he thinned the total forest area every year. Of course, this is completely impractical. Today the challenge of marking large areas and conducting operational harvests is even more difficult because foresters are responsible for larger forest districts than in former times. Nevertheless, ANW is convinced that regular marking with short cutting cycles is an extremely important task for an adaptive *Dauerwald* management.

JG: Here in the U.S., we think that the length of the cutting cycle depends upon the productivity of a site. High site quality promotes higher growth rates, which can be managed with shorter cutting cycles; poor site quality results in stands having slower growth rates, which will require longer cutting cycles. But the method can work in either event.

HR: I agree generally, but *Dauerwald* practitioners in Europe prefer shorter cutting cycles (ranging from three to eight, in the Alps up to twelve years) than American foresters (often fifteen to twenty, sometimes up to twenty-five years, as far as I know). This should be discussed in more detail in future.

From our experience, short cutting cycles are advantageous on very productive sites, in stands with restricted stability (during transformation of overstocked plantations to the *Dauerwald* method), and in forests with very intolerant tree species (so that competitors can be thinned before they die from overcrowding). And I should remind you that the family plenter forests managed by farmers over the centuries worked quite well without fixed cutting cycles—the plenter forest is highly resilient!

JG: In 1935, the famous American wildlife biologist, Aldo Leopold, and five other foresters from the research and management sections of the United States. Forest Service spent three months in Germany studying forestry methods. Leopold found German forests to be very artificial in species composition and structure—widespread even-aged monocultures of spruce or pine instead of close-to-nature mixed forests—and in addition it was overpopulated with deer but lacking large predators. He summarized his German experience in two papers in the *Journal of Forestry*, entitled "Deer and *Dauerwald* in Germany." He reported that Germany presented a plain case of mutual interference between game and forestry, and suggested that Germans had concluded that "production of wood at the expense of soil health, landscape beauty, and wildlife is poor economics as well as poor public policy."[14]

Leopold praised the *Dauerwald* as an elegant compromise between better timber production in the long run in combination with other benefits in ecological health. He also spoke to the very

interesting juxtaposition that better silviculture is only possible with better game management, and at the same time, better game management is possible only with better silviculture. Finally, he brought several conclusions back to offer to American foresters. One was that a generous proportion of each forest should support floral and faunal conservation. Another was to advocate for native forests, and to be suspicious of large blocks of monocultural plantings of species, especially those not native to the vicinity.[15]

HR: ANW members were always strong advocates of regulated deer populations (*Wald vor Wild*) which are a main precondition for the development of mixed-species *Dauerwald*. A recent German research project called BioWild, coordinated by the ANW organization, deals with the effects of different deer hunting strategies on plant biodiversity of several forest communities. The topic has strengthened in the last years in context with efforts for climate change adaptation.

JG: In addition to Leopold, foresters working in cut-over southern yellow pine stands in the southern U.S. studied the *Dauerwald* method in the 1930s.[16] There was an effort at the Harvard Forest in the 1930s to develop management practices that took after the *Dauerwald*, to study natural processes in forest stands and apply that knowledge in the development of silvicultural practices appropriate for forest types in the region.[17]

Hermann, my 95-year-old mother told me last night that her brother visited the Black Forest in the last year of his college forestry education in Pennsylvania in the late 1920s! *Ach, du meine Guete*! (Oh, my goodness!) The Schenck influence and the Hawley reports, Leopold's visit, the interest of American scientists, and visits to Germany from university students and professional foresters, all revealed a strong interest and curiosity in the US about the *Dauerwald* in the 1920s and early 1930s.

HR: You must know, Jim, that a political reason may have been decisive for the weak exchange of *Dauerwald* ideas and experiences between Germany and the USA from the 1930s on: the stigma associated with its brief adoption by the National Socialist regime. *Dauerwald* principles were dictated to the foresters by the National Socialist government from 1933 until 1937. The traditionally deep, romantic "forest feeling" held by many Germans and the holistic ideas of Möller were exploited for the early ideological national socialistic propaganda campaigns.[18] The *Dauerwald* ("permanent forest"), fit to the new notion "eternal forest" (*Ewiger Wald*), which was thought to be a metaphor for the eternal German nation (*German Volk*). One motivation was obviously to win the nobleman owners of large forestland, who were often attracted by the *Dauerwald* concept, for the national socialistic regime.

The prescribed *Dauerwald* approach in forestry practice during early national socialistic times in Germany failed for several reasons.[19] Firstly, the dictation of management practices led to an aversion for it among some influential practical foresters. One prominent example is the Baden head forester L. Leiber; others were academic lecturers (mainly A. Dengler and E. Wiedemann, who were opponents of the *Dauerwald* approach since Möller, but were members of the National Socialists). Secondly, natural regeneration of the forests was made difficult as there was a political will to maintain dense populations of roe and red deer and other game species. Thirdly, in an attempt to increase wood supply prior to the war, target diameters were reduced to a level that caused overlogging of many forests (prescribed raise of cutting quota to 150 percent of the sustained yield!). In summary, the few years of this interrelation between the *Dauerwald*

movement and National Socialist politics led to a large setback for close-to-nature forestry in Germany.[20]

JG: Perhaps the best or most recent U.S. review recently was by Schabel and Palmer in the *Journal of Forestry*, who captured much of the best ideas of Möller and his critics. In 2001, Schabel followed Leopold's published "Deer and *Dauerwald* in Germany—Any Progress?" in the (US) *Wildlife Society Bulletin*.[21] Schabel stated that at least for the time being (the last years of the twentieth century, maintaining deer populations in at least one-third of German forests has become less important than recovery of the forest—*Wald vor Wild*. I assume that Leopold would approve.

HR: Hans Schabel was born and educated in forestry in Germany, emigrated to the US and worked from 1973 to 2006 as a professor of forestry and director of international resource management at the University of Wisconsin–Stevens Point. He carried out frequent visits to Germany together with his students. The late Siegfried Palmer was a German expert for close-to-nature silviculture and adapted forest management plans. He was an advocate of *Dauerwald* and a committed mentor of ANW.

ELEMENTS OF THE *DAUERWALD* ON PIONEER FOREST

JG: So, what elements of the *Dauerwald* might be found here in the mixed oak-hickory-pine stands on the Pioneer Forest?

HR: Well, the current ANW Principles state that "the overall objective of close-to-nature forestry is to supply economic, ecologic, and socio-cultural services of forests for proprietors and society within the frame of social responsibility."

JG: That shares much in common with this mission statement: "The L-A-D Foundation is a Missouri private operating foundation dedicated to exemplary stewardship of Pioneer Forest and other natural and cultural areas and to scientific research, education, public recreation, and encouragement for projects and policies that have a positive influence on the Missouri Ozark region and beyond."[22]

Pioneer Forest is found primarily in six counties of southeastern Missouri, with the largest contiguous block of ownership in northwestern Shannon County.[23] The area has a humid subtropical climate; in Shannon County, for example, the average winter temperature is 4.5°C (40°F), the average summer temperature is 24°C (75°F), the mean maximum summer temp is 31°C (88°F), and the average annual precipitation is 114 cm (45 in).

Ecologically, Pioneer Forest falls within the Current River Hills subsection (223Af) of the Ozark Highlands section (223A), in the Central Interior Broadleaf Forest Province (223).[24] The underlying geological formation is the Salem Plateau, composed primarily of Ordovician cherty dolomite or sandstone, whose origin dates back to geologic uplift more than 300 million years ago. Since then, the primary geologic activity configuring the current terrain has been erosion; the exposed sandstones, shales, and dolomitic limestones have essentially been reduced through weathering and erosion to their current condition. Ozark soils are primarily Ultisols, with everything from new sandy deposits near creeks to well-developed silt loams on benches to thin stony soils on the ridgetops. Generally speaking, site quality in the region is poor, average site

index in managed stands on Pioneer Forest varies from 17 to 23 m (50 to 70 ft) (base age 50).

The topography is rugged. The entire region is highly dissected, with narrow winding ridges in a highly dendritic pattern that fall on steep terrain into narrow valleys that support entrenched streams downcutting to the Current River. Elevations vary from 400 ft. in the floor of the lowest valleys to ridgetops up to 1300 ft. This terrain is a challenge for forest operations. Road are primarily found on the tops of the ridges, and logging occurs such that logs are skidded uphill on long steep slopes to ridgetop landings and logging roads.

The five most common species on Pioneer Forest by volume as of 2017 data are:

- red oaks combined, 41% of volume (primarily black oak, *Q. velutina*; northern red oak, *Q. rubra*; and scarlet oak, *Q. coccinea*),
- shortleaf pine, *Pinus echinata* (29%),
- white oak (21%),
- hickories, *Carya* spp. (4%), and
- others (3%)

All are native to the Missouri Ozarks, and are found in mixed stands whose specific species composition varies somewhat from one site to another. Furthermore, the stands are uneven-aged and show reverse J-shaped diameter distributions, leading to some kind of structural stability and economic constancy.

In 2018, harvests on Pioneer Forest totaled 8 million board feet, bf (~32,000 m^3) of sawtimber[25], 3.5 million bf (~14,000 m^3) of blocking,[26] and 500,000 bf (~2,000 m^3) of white oak stave logs. That total harvest of roughly 12 million bf (~48,000 m^3) was taken on about 6,000 ac (2,400 ha). That's about 2,000 bf/ac (~20 m^3/ha) on average. For a target cutting cycle of 20 years, harvests average roughly 100 bf/ac (1 m^3/ha) annually.

However, on Pioneer Forest, cutting cycles can often be longer than 20 years, and harvests are still less than growth. From 2002–2012, annual growth averaged 130 bf/ac (1,275 m^3/ha), and preliminary growth data from 2017 are even higher. It's pretty clear from these data that Pioneer Forest is falling short of Biolley's suggestion to have the allowable cut equal the growth. For the last sixty years, it made sense for foresters at Pioneer Forest to cut less than the growth in order to build the stocking of the forest; volumes grew from 1,100 bf/ac sawtimber (10.8 m^3/ha) in 1952 to 4,712 bf/ac (46.2 m^3/ha) in 2012. But as PF stands approach full stocking, the time is right to consider whether harvests should be greater in order to harvest growth. The L-A-D Foundation board and the excellent forestry staff at Pioneer Forest are in the middle of discussions on these issues.

Hermann, how do these growth and harvest data compare with ANW forests in Germany**,** and what would ANW logic suggest about managing fully stocked stands in order to harvest the growth?

HR: Unfortunately, we have no separate data set for ANW managed mixed oak forests. Because we do not use this 'board foot' volume in Germany, and because volume may depend on minimum top diameter, the conversion is difficult. The German growth rates are based on all wood pieces with more than 2.7-inch (7 cm) diameter, named *Derbholz*. Nevertheless, these data from PF seem to be very low values compared to oak-dominated forests in Germany, which have

presumably in most cases higher standing volumes (more mature stands) and better growth conditions. The average annual volume production of all measured oak stands in Germany during the period 2002–2012 (according to the 3rd German Forest Inventory) was about 6.6 m^3/ha/year (excluding bark and topwood). But this is not only sawtimber: it also includes fuelwood or industrial wood, which have a good market in Germany.

JG: On Pioneer Forest, profits from the timber sales are used by the L-A-D Foundation, which is a nonprofit organization under the U.S. tax code. Those profits are used to support the management of the Forest, and to conduct ecological stewardship activities on the Forest. In addition, the foundation awards local and regional grants for activities on the forest, on other foundation-owned land not under Pioneer Forest, and in local communities. Projects funded by these grants include restoration of historic structures, wetland restoration, land acquisition, educational scholarships for local students, and community improvement projects.[27]

HR: These outcomes are not only consistent with the principles of the ANW, they are impressive. We have very few forestland owning foundations in Germany that use money from forestry operations for socio-cultural and conservation purposes. In general, *Dauerwald* management in Germany aims to optimize the economic, ecologic and socio-cultural functions, not to maximize or segregate single goals.

ANW members are convinced for instance, that long-term economic success is partly dependent upon ecological and social elements. Nevertheless, some differences occur depending on ownership. Some private forestland owners who pay taxes need more cash flow than public owners. And because German forest laws allow hikers and bikers free access to all forest lands, forestland owners near communities and towns must provide recreation and conservation values important to urban populations. Nevertheless, these objectives can be fulfilled with *Dauerwald*. There is some recent discussion in ANW and in research to develop a market at least for those extraordinary ecosystem services that are beyond legal standards, but currently freely provided.

ECONOMIC ELEMENTS OF THE *DAUERWALD*

JG: To what extent does ANW consider economic principles in close-to-nature forestry?

HR: ANW was founded in 1950 during a poor economic situation after World War II, which was aggravated by severe stability and vitality problems of even-aged monocultures, by overlogging during the national socialistic times and by widespread reparation clearcuts of the allies (on approximately 10 percent of German forestland). So, economic elements have always played an important role.

Management is based on the "plenter principle" of Walter Ammon.[28] Ammon was a Swiss practical forester with more than 4 decades of experience who applied methods normally used in plenter forests, and had success in other forest types as well. The emphasis is put on regular tending and harvesting of stands using the selection system. Regeneration often comes automatically.

Under the *Dauerwald* approach, even-aged regeneration cuttings with a final, complete removal of canopy are not applied; this prevents the sacrifice of future harvest potential, and allows the continuous cover of the canopy to moderate the forest climate and to maintain the development

of regeneration and poles into larger sized classes.

ANW knows that certain economic principles can identify a given approach to silviculture as "close-to-nature" forestry. For example, it's important to use native species in mixed, structured stands under natural conditions, which will lead to development of forests that have what we call "maximum ecosystem stability."

But my personal opinion is that close-to-nature forestry cannot guarantee the maximum stability of an ecosystem. Under changing climatic conditions, we know that there will be a greater incidence of windstorms, droughts, and possibly non-native insect attacks and disease infestations as well. As a result, *Dauerwald* ecosystems will not be free from significant disturbances in future. But *Dauerwald* management leads to well-tended, healthy, uneven-aged and mixed species stands, widespread and frequent natural regeneration, balanced deer populations, functional soils, and a moderate forest climate. These attributes of *Dauerwald* certainly will promote resistance and resilience to these threats that will increasingly affect all forest ecosystems.

JG: Pioneer Forest has a recent example of this concept of resilience in the face of disturbance. In May 2009, a straight-line mesoscale derecho windstorm crossed southern Missouri, and 22,000 ac (8,900 ha) of Pioneer Forest were damaged, 7,000 ac (2,830 ha) with catastrophic blowdown.[29] Normal cutting cycle harvests were suspended, the forestry staff quickly quadrupled their logging crews, streamlined the administration of the salvage sales, and after two and a half years salvaged nearly all of the damaged timber—a total of 30 million bf (~120,000 m^3/ha). This salvage volume was about 1.5 times higher than the annual harvest of standing timber would have been.

HR: ANW believes that using natural regeneration increases the resilience of an ecosystem. Ideally, we would find that stands damaged in windstorms would retain enough growing stock, especially regeneration already in place, so that planting would not be necessary. That's an important economic advantage. A related issue is that ANW does not advocate the use of clearcutting and clearing of land for non-forest uses. Also, if planting is needed, we do not use genetically engineered plant material.

JG: Clearcutting is outside of Pioneer Forest's mission as well. On the clearcutting question, PF does not engage in clearcutting even as an occasional practice. But, most forest managers in America will say that if a dreadful disturbance event such as a tornado occurs, salvage operations might resemble a clearcut and an even-aged stand might result from that. However, PF does not use clearcutting, and from that it follows that PF also does not use planting for reforestation. All regeneration is naturally occurring.

HR: My guess is that PF would leave important structural "legacy" trees, as defined by American forest ecologist Jerry Franklin, that are important elements of stand structure and recovery from disturbance, during a salvage operation.[30] I mention an old principle of ANW: never remove the living trees that survive a disturbance, because they were the most resistant individuals. We think these relict trees increase the resilience of ecosystems. Also, never damage the advance regeneration after a windstorm; don't remove all the slash, and don't straighten or round off the area damaged by the windstorm. Unlike clearcutting or intensive salvage

operations, natural disturbances do not make a landscape more homogeneous.

On another issue, ANW is keenly concerned about the influence of deer in the forest. We strongly believe in "Forests first, ungulates second." Native vegetation should regenerate without artificial protection from ungulates. You must know, Jim, that we have many species that can be affected by browsing, especially oaks and silver fir in Germany which can be very badly damaged.

JG: Well this sounds like Aldo Leopold has renewed his vows on PF! I'm not aware that the foresters at PF think they have a problem with deer browsing to the extent that regeneration is adversely affected by deer.

Deer hunting is a very important cultural legacy especially for rural families in Missouri and across the U.S. generally. Game management laws are the responsibility of states, not the U.S. government, and not private landowners. So the State of Missouri manages the deer herd on a statewide plan, primarily through the sale of hunting licenses. In order to keep hunters happy and to ensure that hunters have deer to harvest, the statewide harvest of deer is controlled. However a hunter is given a maximum number of deer that they can harvest. In the counties where Pioneer Forest is located, it's 2 deer per hunter per year—one antlered and one antlerless. I know that's far fewer than European hunters and landowners would harvest. Moreover, my guess is that deer populations are higher today than they would have been 300 years ago, before European settlers arrived.

HR: In the ANW, we would suggest that deer harvest must include more does than bucks in order to control the population; pure trophy hunters don't do much to regulate a deer population. Do large predators (like wolves, bear, lynx) occur in the PF? Are the winters harsh enough to cause high deer mortality rates? Is the birth rate of deer relatively low in the large non-dissected forest landscape with limited supply of food? The largest blocks of PF probably have few forest roads with light demanding herbs and grasses, no pioneer vegetation because of *Dauerwald* management, and no access to agricultural fields.

JG: Excellent questions, Hermann, and I have no good answers. I agree, harvest of does is important to regulate populations, but most hunters in Missouri are trying to kill a buck. PF does have good numbers of black bear, which can learn to kill deer, especially fawns. There are certainly coyotes on PF as well. Winters in Missouri have been mild recently, but harsh winters are more likely to cause a doe to have one fawn or even none rather than two fawns, rather than to kill the doe. Finally, I don't have data to verify this, but the mature oaks on PF have big crowns and produce a lot of acorns, the availability of which may balance the lack of soft mast in the winter.

HR: Anyhow, I would suggest checking the real deer effect on regeneration in PF by establishment of a few small control fences. Significant differences inside and outside of the fences show up often after a few years, if deer population is a problem.

JG: That's not a bad idea. I know that PF does not use any supplemental means to protect tree seedlings or saplings, such as fencing or tree shelters. The regeneration seems to develop as it should under these conditions, which we think is a good thing. I suspect that there are parts of

Missouri where farmland and pastureland is more intensely intermingled with forests that there is on PF, and issues of deer browsing in the woods is likely to be more of an issue in forestlands that are next to farmlands.

HR: ANW principles also state that silviculture interventions and harvest should be focused on individual crop trees, and that silvicultural treatments are understood as an ongoing process to optimize quality, increment, and vigor of the precious individual crop trees.

JG: This is exactly the way that PF staff manage their stands. PF foresters examine the view of the stand before them and ask, which of these trees are my crop trees, and second, which of the trees competing with the crop trees are of poorer form or quality, a less desirable species, and large enough to be harvested?

HR: When we speak of steady silvicultural interventions and harvest in ANW, we are thinking of several moderate actions per stand and per decade. And this also relates to a desirable attribute in our stands—there is not much variation in growing stock, increment, and utilization at the stand level over time.

JG: The management strategy on PF is at somewhat at odds with these ANW elements. PF stands are harvested on a 20-to-30-year cutting cycle, so a stand will grow 20 years or more before the next harvest occurs. The slow growth rates of these Ozark oak stands means that harvests would have less volume, less value, and less valuable for the loggers to harvest if the cutting cycle was every 10 years or less. And this also means that when PF foresters mark a stand, they might mark as much as one-third to 40 percent of the volume, both in the harvest of crop trees and the harvest of trees to release the next age class of crop trees being developed.

I don't think I mentioned that Pioneer Forest has one of the best continuous forest inventory (CFI) datasets on any private forest lands in the region. Roughly 450 plots are measured every five years, and each tree on each plot is tagged and remeasured. The CFI data show that the volume and value of high-quality trees has improved dramatically since 1950, and continues to improve over time. So not only do PF foresters know how the overall forest is growing, they have a good idea about how much diameter growth and volume growth a tree of a given species and a given size will have until the next cutting cycle harvest in 20 years.

HR: I understand the argument. In European *Dauerwald* (with higher growth rates and shorter cutting cycle), a harvest of more than 25 percent to 30 percent of the standing volume (or basal area) per entry is unusual and may be critical, for example because of severe logging damage, a loss of structure and stability, decrease of growth, or development of a dense competing ground vegetation. The normal range in non-labile stands is between 16 and 22 percent and this is no problem for the loggers.

One additional silvicultural information, Jim, would be very interesting for ANW: what target basal area after cutting cycle harvests is strived for by the Pioneer foresters? The target basal area in European *Dauerwald* with oak dominance is in the range of approximately 12 to 17 m^2/ha (approximately 50 to 75 ft^2/ac), dependent upon oak species (light demand) and site productivity.

JG: The foresters at Pioneer Forest use a stocking guide developed from upland hardwood stands by Gingrich to monitor stand growth and development in a general way.[31] Gingrich

showed that stand structure had little effect on stocking, and thus stocking could be generally estimated using stand density and basal area. Marking on Pioneer Forest is designed to leave a residual stand in the slightly understocked condition, slightly below the B-line of stocking on the Gingrich stocking chart, and thus a range of residual basal area of roughly 55–60 ft^2/ac (12.5–14 m^2/ha) is a general rule of thumb when PF foresters mark their stands. Intuitively, leaving the stand slightly understocked provides growing space for existing saplings and poles, as well as for new seedlings.

This brings up another point that might be different in the U.S. on private forestlands generally, and on PF lands in particular, compared to stands managed under ANW—how timber is marked and sold.

On most private forest lands in the U.S., a landowner will hire a forester to mark the trees for harvest. The forester then prepares a sale package for local loggers that includes the species, sizes, and volumes that are marked, and a minimum bid price the forester would accept. Several loggers may bid on the sale, and the high bid usually wins. At that point, the logger has purchased the standing marked trees from the landowner. The logger cuts the trees he owns, skids them to the deck, and hauls them to the mill. So the interesting interaction between the logger and the forester is that the logger only has rights to harvest the marked trees, and all the trees still standing and unmarked are the property of the landowner. Careless logging, where unmarked trees belonging to the landowner are damaged by the logger who is hauling trees that he has purchased from the landowner, can be a source of conflict between the forester and the logger.

This process is a bit different on Pioneer Forest, and requires mutual trust and respect between the forester and the logger, so much so that a good working relationship between the PF forester and the logger is essential. The Pioneer forester will mark a stand with an eye toward the future, and the logger will have the challenge of efficiently cutting and hauling the trees that are marked. However, the Pioneer forester only marks enough timber to last for a week or two ahead of the logger. The forester and logger meet at least once a week, and the Pioneer forester collects the weight scale tickets and payments from the logger when they meet. That also gives the logger a chance to explain any operational issues that are occurring during the harvest, and for the Pioneer forester also to address any concerns about the quality of the harvesting operation.

What has happened over time is that PF foresters have developed excellent working relationships with the loggers who harvest PF stands, and both forester and logger understand the issues that the other faces, and they work together to resolve them. The logger is well aware that future harvests may depend on careful harvesting in the current sale, and the forester is well aware that the silvicultural goals on PF can only be met if loggers are willing to harvest PF timber.

HR: A stumpage sale is only used in Germany for full mechanized harvests using harvester and forwarder technology. In all other cases the landowner pays the logger to harvest the trees and skid them to a roadside deck. The landowner will then advertise the logs for sale, and sell them directly to a mill. Transportation costs are then paid by the mill. Very high-value saw timber logs (veneer) may be marketed via auction (highest bid procedure) organized by state forest service or forestland owner cooperatives.

ANW forestland owners are very critical with regard to trees damaged during logging. A number of bad experiences have led to the practice where a landowner pays a logger by the hour (a fair wage that is negotiated), rather than by the volume harvested. And well-educated and experienced loggers are certainly preferred.

JG: This opens another explanation about the way PF manages their forests. Land ownership in the U.S. is based on complicated surveying procedures. Suffice it to say that the lands owned by Pioneer Forest are found in about 30 *townships*, a square unit of land measurement 6 miles (9.65 km) long on each side. Each township contains 36 *sections*, a square unit of land that is 1 mile (1.6 km) on each side, and contains 640 acres (259 ha). There may be many different stands within a section, if we would define them using a standard textbook approach. But PF foresters don't manage by stands, they manage by sections. In some sections, PF only owns 30–40 acres (12–16 ha), and in other sections PF might own all 640 acres. Regardless, all of the PF ownership in the section being harvested is marked and harvested at the same time.

But because these forests are so heterogeneous in aspect, slope position, site quality, and landform, the PF foresters are experts at making adjustments in their timber marking decisions based on the specific conditions that they encounter. And they might make different decisions as they walk another 50–100 meters through the forest, based on changes in the condition and structure of the forest.

HR: In Germany, the even-aged management approach creates individual stands with specific age, tree species proportions and density (well defined, often artificial stand targets and strict prescriptions). But ANW`s management is based on working larger areas of approximately 10–40 ha (25–100 acres) which might encompass different stands. And when these working compartments are marked on their regular entry, local flexibility and patience are crucial. Different stand and site conditions are considered during marking, like in PF, and foresters are aware that silvicultural targets, for instance uneven-aged structure and high-value timber production, need enough development time. This step-by-step approach—repeated entries, repeated observations—fit to Möller`s *Dauerwald* principle *Stetigkeit* (constancy). And in addition, ANW members realize that natural disturbances, successions and natural dynamics of stand structure are attributes of different forest ecosystems and should be integrated in silviculture. Sometimes silvicultural targets have to be adjusted. A great new challenge is climate change adaptation.

Tree species which are adapted to specific local site conditions and presumed future climate (higher temperatures, more drought and storm events) are promoted. ANW works with natural regeneration wherever possible, enabling genetic diversity and natural root development, and encourages the natural development of stands by heterogenous thinning. In addition, ANW uses the approach of maintaining continuous canopy cover in managed stands, because the shelter provided by the overstory protects regeneration from extremes in climate. A permanent loose overstory in *Dauerwald* leads to a more moderate forest climate; compared to clearcut stands, *Dauerwald* stands have a smaller range of temperatures, lower frequency of extremes like heat or frost, lower wind velocity within the stand, and less direct solar radiation causing less danger of drought. The canopy may also act in some cases as a shelter against heavy snow package or ice break. And it helps the regeneration develop into larger size classes with good quality; semi-shade promotes self-pruning, self-thinning and tree-topped growth.

JG: If you are speaking to protection against snow and ice, I think because the PF manages stands dominated by hardwoods and shortleaf pine in the overstory, and intends to regenerate primarily oaks in several age classes over time beneath that overstory, issues with snow and ice are less of problem than they might be in Europe. I could see how snow and ice might be an issue especially in Norway spruce–European silver fir stands such as those in Biolley's former forest region (Neuchatel) in Switzerland that I visited in the summer of 2014.

We do experience ice storms in the Missouri Ozarks, and the accumulation of ice can break branches and cause trees to fall. In the summer, occasionally windstorms that are less severe than the derecho I described previously will strike these forests, and windstorms such as these can cause substantial damage locally. The several age classes of oak that are found in the mid-story and understory of these stands provide a certain degree of insurance against the loss of overstory trees in these common Ozark disturbance events.

HR: Ultimately, ANW practices are intended to ensure the protection and improvement of site productivity via a site-adapted mixture of tree species, steady shelter (overstory) and access to the area only via permanently maintained skid trails.

JG: This relates to one of the elements of uneven-aged silviculture in the United States. The method has been a very effective tool to recover understocked stands back to full stocking. This is evident for example, in the uneven-aged Farm Forestry southern yellow pine stands at the U.S. Forest Service Crossett Experimental Forest—an entirely different forest type in entirely different ecological conditions in south Arkansas that the members of ANW will also find interesting.[32]

ECOLOGICAL PRINCIPLES OF THE *DAUERWALD*

JG: Hermann, what about the ecological principles respected by close-to-nature silviculture?

HR: Trees should be assessed and managed following their economic, ecologic, and social functions. The historic guideline "The ugliest (worst) tree will be cut immediately, the better one remains" is still valid in general. However, we also retain some trees with high ecological value (for instance cavity trees, old culls, snags) or rare trees with striking aesthetics.

JG: That's a common way the PF foresters describe their silvicultural approach: "Cut the worst trees and leave the best," provided the trees have a DBH>8 in (20 cm) and that there is a market for sawlogs of the species being cut. But no attempt is made to remove all dead and dying trees.

HR: The ANW recommends that old growth elements are integrated into management; secondly, ANW advocates that responsible silviculture needs some plots that are not managed, so that foresters can understand the effects of no management as well as the effects of management. There may also be a justification to keep unmanaged stands and landscapes as a biological or ecological reserve.

JG: I'm not sure about how to define these old-growth elements; but PF meets this in two ways. First, there's a good likelihood of finding trees 200 years old or older in every section of Pioneer Forest. One of our xeric white oak species, post oak (*Q. stellata*), is found as a scattered tree especially on ridgetops across the PF property, and a tree 16–20 in (40–50 cm) DBH may easily

be 200 years old or more. Its age is a larger number than the dollar value the tree would be worth as a harvested sawlog! Similarly, the market for shortleaf pine sawlogs is not very strong in the region, and I have personally touched many shortleaf pines on PF whose age of the tree (>80 years) exceeds their sawlog dollar value (<$80).

Perhaps that's an alternative definition of old growth! Does the age of the tree exceed the dollar or Euro value of the sawlogs that the tree contains? If yes, retain it as old growth! Well, Hermann, I'd have to think about that. It wouldn't apply to veneer crop trees, but here tonight in a hotel room in Salem, Missouri, it's an interesting idea to consider.

HR: Jim, this is a very interesting idea, but may be not very operational. Marking foresters normally do not know the age and interior quality of trees before cutting, they realize only large diameters.

JG: And to follow up on this element, PF has reserved several thousand acres as "wilderness areas," where active management is no longer being conducted. That's about 2 percent of the PF ownership, in addition to the thousands of acres of streamside management zones, small parts of managed sections too steep to harvest, and other areas where trees will not be cut. It's likely that as much as 5 percent of the area of PF will never be harvested, but much of it is interspersed across the PF landscape.

HR: ANW also thinks that the structural diversity promoted by *Dauerwald* management creates canopy gaps for species across the spectrum of shade tolerance, both those that benefit from shade as well as light-demanding species; this management follows the pattern of the old growth and decay phases of forests.

JG: There is quite a bit of structural diversity on PF stands; most have had three cutting cycle harvests since the 1950s, and some have had four, yet each cutting cycle harvest releases hardwood saplings for recruitment into the mid-story and eventually into the overstory. Foresters at PF do not deliberately make canopy gaps, but the harvest of a white oak with a DBH>24 in (60 cm) certainly makes an opening in the canopy. Generally, saplings of the desired species will be in the understory of these stands, and when the crop trees are harvested, existing saplings respond. The continued development of saplings into poles, and of poles into sawtimber, depends on continuing to make those cutting-cycle harvests every 20–25 years.

HR: Larger gaps in German *Dauerwald* forests, caused by natural disturbances, are more and more used to integrate early successional, shade intolerant species. For example, the pioneer species silver birch *(Betula pendula*) on acid soils, treated as a weed in former times, has diverse ecological functions; silver birch crop trees can produce valuable timber in short time.

Another ecological element important to the ANW is to maintain soil fertility with the preservation of dead wood elements. ANW management does not advocate whole-tree harvesting, which we define as removal of biomass smaller than 7 cm in diameter in addition to conventional stem wood. This has increasing importance in Germany, because of a current boom of biomass removal for energy wood production. Our experience clearly shoes that whole-tree harvesting is detrimental for plant nutrition and organic carbon contents of widespread poorer soils.

JG: Trees that die for some reason between cutting cycle harvests are rarely salvaged, unless large numbers of trees die during a disturbance event like the derecho. Because of this scattered mortality, there are usually standing dead snags and fallen dead trees of sawlog size scattered across the PF. And after each cutting tops remain on site to decay.

HR: Another key ecological element is that ANW landowners and foresters use appropriate harvest and skidding techniques applied at the appropriate moment to protect stands and soils. In Germany, the topic of "soil protection" with regard to minimizing soil compaction by heavy harvesting/logging machines is strongly discussed; it is a key element of the forest certification systems used in Germany.

Skid trails must be marked and permanently maintained, so that the same skid trails are used in harvests over time. Some forestland owners establish skid trails every 20 m (to enable a fully mechanized harvest), but ANW members often use skid trails with a distance of at least 40 m, which means that soil compaction occurs on not more than 10 percent of the area. Logging during wet periods or on wet sites is avoided under these circumstances. Unfortunately, there are only very few examples of cable crane technology for logging, because the costs are still extremely high. Skidding logs with horses has lost importance in the last decades and is only used for small diameter logs, often in combination with machines. All these soil protection measures reduce the profit that a landowner could obtain, but they save long-term site productivity and sustainability.

JG: I mentioned previously that PF foresters work closely with the loggers who harvest trees from PF lands, and careful attention to best management practices of logging and skidding are part of the weekly conversations between the foresters and the loggers. For example, cable skidding is done to minimize soil disturbance in sensitive riparian areas, and logging with machines is suspended when soils are waterlogged due to wet weather.

However, the permanent use and documentation of skid trails isn't an element of management at Pioneer Forest. First, the nature of the terrain guides harvest activity. Skid trails are often found on the sides and backs of the ridges that come up from the creeks to the ridgetops. And all of the log decks and haul roads are on the ridges, and some of these ridges are fairly narrow, which may in fact become a de facto permanent skid road or haul road. We have not yet come up against any issues associated with failure to mark and use the same parts of the forest for skidding and hauling.

HR: Another ANW principle is that close-to-nature forests are determined by native tree species adapted to the site; but we do allow for the use of some non-native site adapted tree species which can be admixed individually or in small groups. On the other hand, we encourage the promotion of ecologically important or rare tree species.

JG: Same thing on Pioneer Forest. With the species diversity that is found on PF, and the abundant regeneration of desired species, PF hasn't needed to introduce any non-native tree species on the property. On the other hand, PF foresters watch for uncommon species, and will manage them along with the more common tree species. If these rare native species become crop trees, foresters will occasionally harvest them as crop trees because sometimes their wood is valuable. Examples include sassafras (*Sassafras albidum*), black walnut (*Juglans nigra*), black

cherry (*Prunus serotina*), and sugar maple (*Acer saccharum*), all of which are very common in the northern part of the U.S., but less common than the oaks in the Missouri Ozarks. But all produce excellent cabinet-quality lumber.

HR: Because of our respect of naturalistic processes, the ANW also generally rejects the use of foreign substances such as herbicides or biocidal products.

JG: PF also avoids using herbicides or pesticides, so that is perfectly consistent with ANW practice.

HR: ANW also believes that genetic diversity should be ensured by widespread and quasi-continuously occurring natural regeneration.

JG: This is an interesting issue for oak regeneration in the Ozarks. Let me explain. Oak acorns are the result of genetic recombination, and are genetically related to their parents but unique. The sea of acorns of both black and white oak that germinate into seedlings and saplings create a diversity of genotypes. In the future, if climatic conditions change, the operating principle is "Let nature sort them out"—the best individual trees in the future will result from the best interaction of their own genetic makeup with the prevailing environment that the seedlings encounter. However, some oaks regenerate from sprouting, and sprouts are genetically identical to the parent tree. We also know that sprouting is inversely related to stump diameter; more sprouts come from smaller stumps. So the sprouts tend to come from the smaller trees, and when smaller trees are harvested on PF, they are invariably the poorer-quality trees, not the better-quality trees. Clearly, the foresters at PF prefer seedling and saplings from acorn germination rather than sprouts from the poorer-quality trees of the previous generation. I'd guess that virtually all the oak trees that become crop trees are from acorn germination, because their single stem and straight form does not suggest that they are of sprout origin.

HR: There is a third category in the philosophy of ANW that relates to the social and cultural importance of forests. ANW recognizes the importance of forests for the mental and physical wellbeing of people, particularly in congested areas.

JG: Well, the Missouri Ozarks are not exactly congested with people! But there's no doubt that a day spent on Pioneer Forest lands, or the rivers that flow through the Current River Hills in the southern Missouri Ozarks, is emotionally satisfying.

HR: The application of close-to-nature forestry means that the woodlands satisfy the best sociocultural expectations of society. Important elements include providing jobs in rural regions in forestry and timber industries, conservation of water quality, prevention of soil erosion in mountains, utilization of forest products to mitigate climate change via lower carbon emissions, forests as areas for recreation and health, and consideration of old forest utilization techniques as cultural goods.

JG: Well, I think I've already covered some of these elements—the jobs provided by sustainable timber harvests, the conservation of the ecosystem, for example. I don't think I stated that PF has an open recreation policy; local people are welcome to hunt and fish anywhere on PF lands. The L-A-D Foundation has easements with the National Park Service to provide access to the scenic rivers in the Ozarks, including the Current River and Jack's Fork River, two famous rivers for

water-based recreation.[33] And the foundation is also working with federal and state partners to restore Dillard's Mill, a working grist mill, and to preserve the mill at Greer Springs, on PF land near the Mark Twain National Forest. And as I stated before, because of the nonprofit status of the L-A-D Foundation, the funds generated from PF are administered by the foundation to support many of these and other philanthropic activities by the Board.

HR: My concluding opinion is, that Pioneer Forest is an impressive long-term example of successful uneven-aged forest management in mixed oak-pine forests, by no means a matter of course! It is similar in several ways to the ANW style of *Dauerwald* in Germany. And I am convinced, that foresters and forestland owners of both countries with same close to nature attitude can still learn from each other, especially related to some aspects with different approaches.

JG: I think I saw in the brochure you gave me that the ANW was founded in 1950, as a working partnership of forestland owners, foresters, scientific personnel, and other forest stakeholders to practice multifunctional and environmentally friendly forestry. Isn't it a remarkable coincidence? That's almost exactly the year that Leo Drey began to acquire the Pioneer Forest lands in 1950, and very much for these same reasons. It's interesting to see how in nearly seven decades of management, the operations at Pioneer Forestry seem in more ways than not to embody the ANW principles. We'll look forward to seeing whether the ANW experts feel the same way after they have visited the Pioneer Forest.

NOTES

1. The ANW is an association of forest owners, foresters, scientists, and those interested in forests.
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4. Carl Alwin Schenck, *The Biltmore Story: Recollections of the Beginning of Forestry in the United States*. Ovid Butler, ed. (St. Paul, MN: American Forest History Foundation, Minnesota Historical Society, 1955).
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6. Henri-Edouard Biolley, "The Jardinage Cultural," *J. for. suisse* 52(1901): 97–101 and 113–32.
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8. K. Gayer, *Der gemischte Wald, seine Begründung und Pflege insbesondere durch Horst-und Gruppenwirtschaft* (*The Mixed Forest, Its Establishment and Tending Especially with Groups*) (Berlin: Verlag Paul Parey, 1886).
9. Alfred Möller, "*Kieferndauerwirtschaft* I (*Dauerwald* Forestry with Pines)," *Zeitschrift für Forest und Jagdwesen* 52 (1920): 4–41; and Alfred Möller, *Der Dauerwaldgedanke, sein Sinn und seine Bedeutung* (*The Dauerwald Concept, Meaning, and Significance*) (Berlin, Springer Verlag, 1922).
10. Ralph Hawley, "The Continuous Forest—A Review of Several Articles Appearing in German Forestry Journals, 1920 to 1922," *Journal of Forestry* 20: 651–61.
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12. D. R. Helliwell, "*Dauerwald*," *Forestry* 70 (1997): 375–79.
13. W. Ammon, *Das Plenterprinzip in der Waldwirtschaft; Folgerungen aus 40 Jahren schweizerischer Praxis* (*The Plenter Principle in Forestry. Conclusions of 40 Years of Swiss Practice*) (Bern, Switzerland: Verlag Haupt, 1951), 158.
14. Aldo Leopold, "Deer and *Dauerwald* in Germany. I. History," *Journal of Forestry* 34: 366–75; and "Deer and *Dauerwald* in Germany. II. Ecology and Policy," *Journal of Forestry* 34: 460–66. For more on this trip, see: Susan Flader, "Leopold on Wilderness," *American Forests* May/June 1991: 32–33, 66–68.
15. Leopold, "Deer, II."

16. Donald Bragg, “The Development of Uneven-Aged Southern Pine Silviculture Before the Crossett Experimental Forest,” *Forestry* 90, 2017: 332–42.
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